ASSESSMENT OF HISTORICAL TRANSMISSION CONGESTION IN THE EASTERN INTERCONNECTION FOR 2015 v2.0

DEPARTMENT OF ENERGY

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DISCLAIMER FOR PUBLICATIONS

Revision History

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1.1	02/19/2019	Edited with Comments per DOE, FERC, PJM, and SOCO	OATI
2.0	02/27/2019	Updated Report Approved	OATI

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List of Acronyms and Definitions

ACRONYM	DESCRIPTION
AECI	Associated Electric Cooperative, Inc.
AFC	Available Flowgate Capability
ATC	Available Transfer Capability
AZ_NM_SNV	Arizona-New Mexico-South Nevada
BA	Balancing Authority
DAM	Day-Ahead Market
DOE	Department of Energy
DFAX	Distribution Factor
EIDSN	Eastern Interconnect Data Sharing Network, Inc.
EIPC	Eastern Interconnection Planning Collaborative
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
FRCC	Florida Reliability Coordinating Council
GTL	Generation-to-Load
HAM	Hour-Ahead Market
HQ	Hydro Quebec
IDC	Interchange Distribution Calculator
IDCWG	Interchange Distribution Calculator Working Group
IESO	Independent Electricity System Operator
ISO	Independent System Operator
ISONE	ISO New England Inc.
JCM	Jointly Controlled Market
LBNL	Lawrence Berkeley National Laboratory
LGEE	Louisville Gas and Electric
LMP	Locational Marginal Price
MAPP US	Mid-Continent Area Power Pool
MHEB	Manitoba Hydro
MISO	Midcontinent Independent System Operator, Inc.
MRTO	Monitoring Regional Transmission Organization
MTM	Market-to-Market
MW	Megawatt
MWh	Megawatt Hour
NERC	North American Electric Reliability Corporation
NMRTO	Non-Monitoring Regional Transmission Organization

ACRONYM	DESCRIPTION
NWPP	North West Power Pool
NYISO	New York Independent System Operator
OASIS	Open Access Same-Time Information System
OATI	Open Access Technology International, Inc.
OATT	Open Access Transmission Tariff
PJM	PJM Interconnection, L.L.C.
POD	Point of Delivery
POR	Point of Receipt
RMPA	Rocky Mountain Power Area
RT	Real-Time
RTO	Regional Transmission Organization
SOCO	Southern Company Services, Inc.
SPC	Saskatchewan Power Corporation
SPP	Southwest Power Pool, Inc.
TOP	Transmission Operator
TLR	Transmission Loading Relief
TRU	Transmission Reservation Utilization
TSR	Transmission Service Request Or Reservation
TTC	Total Transmission Capability
TVA	Tennessee Valley Authority
VACAR	Virginia-Carolinas Area
WAPA	Western Area Power Administration
WAUE	Western Area Power Administration, Upper Great Plains East
WECC	Western Electricity Coordinating Council

1. Introduction

The U.S. Department of Energy (DOE), through the Lawrence Berkeley National Laboratory (LBNL), issued a contract to Open Access Technology International, Inc. (OATI) to develop a historical transmission congestion analysis for the Eastern Interconnection. A methodology was developed and vetted by industry experts before performing the historical data analysis. The metric calculations were performed using the following:

- Information from the Open Access Same-Time Information System (OASIS).
- Schedule/webTag data.
- Interchange Distribution Calculator (IDC) data.
- Real-Time (RT) flow data.
- Market operations data.

Transmission Operators (TOPs) provided the RT flow and market operations data. For collecting the remaining data, webTag, IDC, and OASIS were used for the sub-regions. Permission was granted for usage of this data by the individual sub-regions.

The last historical transmission congestion analysis study was completed in 2015 with the DOE publishing a report (the "2015 Study") entitled "ASSESSMENT OF HISTORICAL TRANSMISSION SCHEDULES AND FLOWS IN THE EASTERN INTERCONNECTION." This report identified and aggregated schedules and actual flows between sub-regions defined by the Eastern Interconnection Planning Collaborative (EIPC) in a 2011 study. This last study report was performed for the years 2011, 2012, and 2013, and only had limited analysis related to schedules and actuals flows. The DOE and OATI received several comments from industry experts regarding how to improve study analysis by including analysis of OASIS reservations, IDC flowgates, schedule curtailment, and market data.

Therefore, this study analyzes historical transmission congestion for the year 2015 by adding OASIS reservations and Available Transfer Capabilities (ATCs), Transmission Loading Relief (TLR) curtailment, and market data in addition to the schedule and actual flow data to complement previous study results.

A new methodology and new metrics were identified and developed for additional data used in this study. It was decided that the methodology should be reviewed and commented on by the industry experts before starting on the detailed study work. A first draft of the methodology

was issued and presented to the industry on August 25, 2016. After several industry discussions, including generation of some preliminary results, the methodology draft v5.0 was issued as a final study methodology entitled "PROPOSED METHODOLOGY FOR HISTORICAL TRANSMISSION CONGESTION ANALYSIS ON EASTERN INTERCONNECTION YEAR 2015" on October 05, 2016.

It was also resolved to further refine and test the methodology by performing a pilot study with limited interfaces and one sub-region. The goal of the pilot study was to review the results with participating regions to validate and refine the study methodology.

The following sub-region and interfaces were selected for the pilot study. All the interface metrics were calculated in the direction as listed below.

1. Sub-region:
    - PJM.
2. Interfaces:
    - SOCO > MISO.
    - SOCO > TVA.
    - PJM > MISO.
    - MISO > SPP.

Detailed discussions were held with the pilot study sub-region to develop updated metrics that would best represent the sub-regions and interfaces. All metrics developed were presented to the sub-regions for their review and comments. In discussions, it was decided to include an additional metric representing a schedule count above the Total Transmission Capability (TTC) for interfaces. It was also decided to remove duration curves from the full study. After discussion and review of results, the pilot study report was released to DOE and pilot participants on May 29, 2018.

The purpose of the pilot study was to test the methodology and to fine tune the metrics before they were implemented for the remaining Eastern Interconnection sub-regions and interfaces. After the successful completion of the pilot study, a complete historical transmission congestion analysis was performed for the Eastern Interconnection sub-region and interface for the year 2015. This study report summarizes the results from this complete historical transmission congestion analysis for the year 2015.

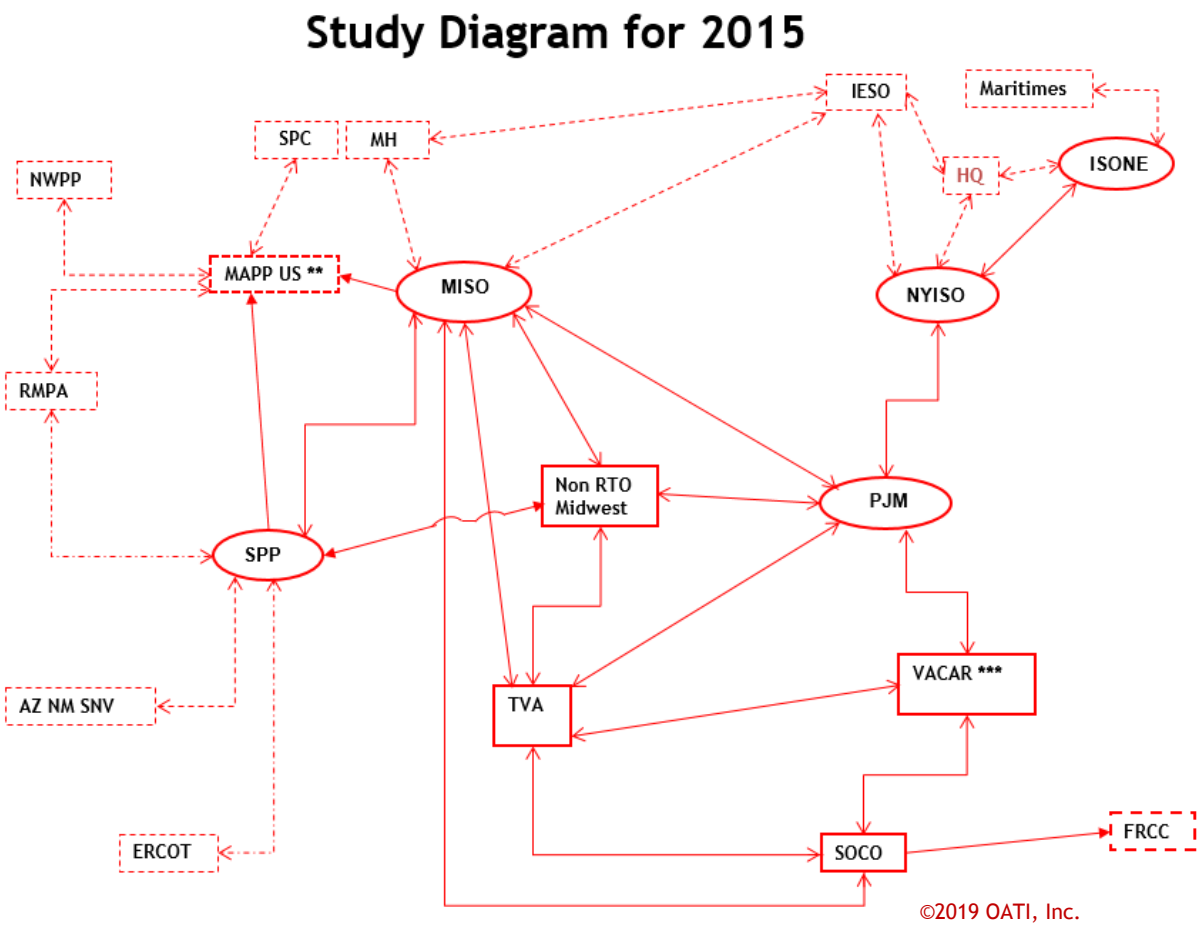
2. Background of the Study

The purpose of this study was to identify transmission system limitations both in the Independent System Operator (ISO)/ Regional Transmission Organization (RTO) and non-centralized electricity markets based on the analysis of 2015 data. Understanding and analyzing flows of electricity on the transmission grid can provide insight into how traditional utilities, power marketers, and others use the Eastern Interconnection system. It can indicate which interfaces see consistent, heavy use, and at what time of the year these interfaces are heavily loaded. In addition to the metrics, this report also provides visuals of schedules versus actual and other data.

The scope of the study included gathering and developing metrics of historical data for the calendar year 2015, and drawing conclusions about transmission system limitations that may have constrained the transfer of electric energy. The study team collected publicly available data from all OASIS and market sites in the Eastern Interconnection, where data were available on these sites. In cases where the data were not publicly available, the market and/or OASIS node operators provided the data for the study. In addition, IDC data were obtained with permission from the involved members IDC Working Group (IDCWG). Based on the available data, a set of metrics were developed to determine the important limitations of the transmission system.

This study is focused on historical data of 2015, however there may be some significant changes to the transmission system from year to year. The data collected for this report is a snapshot of the data for 2015. It will be helpful in the future studies to look at time series graphs to see the trends of the metrics and graphs, as suggested by reviewers.

Figure 2.1 shows the Eastern Interconnection, sub-regions, and interfaces of this study. Each node is shown by an ellipse or rectangle. Nodes and interfaces with solid lines were considered as a sub-region for this study. Nodes and interfaces with doted lines were not included in this study. Western Electricity Coordinating Council (WECC) and Canadian sub-regions and interfaces have been included in the diagram, but were not considered for metric calculations. Tie line data between the Balancing Authorities (BAs) form the basis for calculating the actual flows.



**MAPP US (WAPA) was transitioned to SPP on 10/01/2015.
***VACAR consists of DUK and Progress. For PJM-VACAR interface, VIRGINIA and DOMINION will be represented as part of PJM.

Figure 2.1: Sub-regions and Interfaces for Study

The original sub-region and interfaces published by the EIPC study were modified based on the changes made in the various market footprint and sub-regions since the EIPC study was originally published. These modifications to the regions and interfaces were due to the companies joining Midcontinent Independent System Operator, Inc. (MISO), Southwest Power Pool, Inc. (SPP), or PJM Interconnection, L.L.C. (PJM). Most of the Mid-Continent Area Power Pool (MAPP US) transitioned to SPP on October 01, 2015, therefore MISO-MAPP US, and SPP-MAPP US interfaces were studied only for January-September 2015.

The study metrics were calculated for the interfaces between sub-regions, but not for any internal sub-region interfaces. The study also includes analysis of the selected flowgates and/or markets to capture limitations internal to the sub-regions.

3. Congestion Metrics Overview

Study methodology development defined the following groups of metrics based on the historical data available:

- OASIS Data metrics.
- Schedule and actual flow metrics.
- IDC (TLR) metrics.
- Market metrics.

Each metric group brings in different aspects of the congestion. The OASIS metrics provides congestion that was experienced by the energy traders and schedulers during the planning stages of system operations. Energy schedules provide the limitations experienced during day-ahead scheduling and actual flows provide the loading of the interfaces during RT operation. IDC/TLR metrics provide transmission constraints (TLR flowgates) and curtailment of energy due to operational limitation including transmission overloads. The market metrics provide binding constraints and the cost of congestion due to limitations with the market operation.

In the methodology document entitled "PROPOSED METHODOLOGY FOR HISTORICAL TRANSMISSION CONGESTION ANALYSIS ON EASTERN INTERCONNECTION YEAR 2015," tables 4-1 to 4-11 summarize the various metrics for these groups and provide details of how these metrics were computed.

Table 3A provides a summary of the metrics developed and the data used in this study along with the expected findings from these metrics (same as Table 2-1 of the methodology document).

Metrics/Item Measure	Data	Expected Findings
OASIS ATC, Reservations	Reservations, ATC, and AFC	Limitations faced by the Transmission Customers during the transmission reservations process. Report total count of negative ATC/AFC and reservations exceed a percentage of TTC. Top five most limiting flowgates will be reported. This will identify congestion during the reservation time.
TLR Energy Schedule Impacts	Energy Schedules, Actual Flows, TLRs including total number	Limitations due to curtailment of schedules and other operating issues. Report total TLR counts and MWs.

Metrics/Item Measure	Data	Expected Findings
	of Hours, Level, and MW curtailed	Report top five most limiting constraints for each sub-region and rank them based on yearly count by Firm and Non-Firm curtailments. This identifies congestions from schedules and operation issues.
Market Impacts	RT binding constraints, shadow price, and Actual Flows	Limitations due to market flow and market operational issues for Market sub-regions. Report number of binding constraints, counts, and congestion costs. Report top five binding constraints based on yearly count and congestion cost. This identifies congestions during the market operation.
Interface Correlations	OASIS metrics and TLR metrics	Summarization of each interface based on the OASIS and TLR. This will summarize congestion on an interface.

Table 3A: Summary of Metrics and Expected Findings

The metrics identified were developed only if such metrics were applicable for a sub-region and also if data were available to develop the metrics for the year 2015.

It should be noted that this study primarily focused on inter-regional congestion rather than internal sub-regional congestions as internal and local sub-regional congestion is not in the study scope. Furthermore, sub-regions/RTOs regularly perform internal congestion analysis for their regions and there is no need to duplicate those efforts. Therefore, this study will mainly address congestion between sub-regions and only a limited flowgate analysis and market binding constraint analysis performed to identify internal congestion within the sub-regions.

Section 4 of the methodology titled, “Proposed Congestion Methodology and Congestion Metrics Development” provides an overview of the congestion metrics to understand how transmission is managed in the Eastern Interconnection. It discusses the temporal relationship among the elements, the differences in practices among Eastern Interconnection Transmission Operators in the way the elements are implemented, the data that are available to calculate metrics (which quantify aspects of these practices), and finally, the interpretation and significance of the metrics in understanding congestion in the Eastern Interconnection.

3.1 OASIS Metrics

Because of Federal Energy Regulatory Commission (FERC) Order 889, all TOPs are required to post ATC, Available Flowgate Capability (AFC), and Transmission Service Request or Reservation (TSR) information on OASIS. Order 889 specified the transmission information TOPs to post on their OASIS including available transmission capacity, transmission service products, ancillary service offerings and prices, transmission service requests and responses, posting facility status, transmission service schedules, and other transmission-related communications. Transmission Customers use OASIS for reserving transmission service and checking transmission availability. Customers make transmission reservations for firm and non-firm transmission usage for varying time horizons, ranging from next-hour to several years in future.

For most of the Eastern Interconnection, "effective" ATC is posted for BA-to-BA interfaces (paths) which represent the available transfer capability on the interface. In addition to the ATC posting, AFC is also posted for flowgates to capture all transmission constraints. When a customer makes a TSR request, the Transmission Provider will evaluate this TSR and approve or deny the TSR based on the posted ATC/AFC. A confirmed TSR is required for scheduling the energy between BAs. The RT operation may curtail these schedules to mitigate any transmission system overloads.

The following OASIS metrics were developed for interfaces in this study:

1. **Zero ATC Count for interface**: This metric provides the total yearly count of zero ATC on each interface. It should be noted that all TPs will start posting ATCs for a path two years in advance from the operating time and then update these posted ATCs monthly, daily, or hourly until the operating time based on the NERC ATC posting requirements. ATC values used in this study are taken from last updated value from OASIS. This last ATC value could be significantly different from values posted year or two years ago. For example, ATC could be significantly positive year ago but decreased over the course of time to zero due to approval of the new transmission services since the prior posting, or due to scheduled or forced outage of the transmission since the last posting, or better or more precise in the input data used the ATC calculation such as load forecast and generation dispatch. It is also possible that ATC could be zero a year ago but increased over the course of time to positive due to expiration of existing transmission reservation, or additional transmission capability added to the system, or better or more precise in the input data used the ATC calculation

such as load forecast and generation dispatch. This study uses the last posted value for the ATC and TTC and schedules.

2. **Zero AFC Count for flowgate**: This metric counts the number of instances where the AFC for a flowgate was zero for a given hour, and identifies the five most limiting flowgates for the sub-region (this metric was not calculated since AFC data were not readily available for some regions).
3. **TSR (MW) Count metric for interface**: This metric counts the number of firm and non-firm reservations that were refused or confirmed on each interface. In this metric, refused TSR percentage was also calculated using the below formula.

$$\% \text{ Refusal} = \frac{\text{Refused TSR Count}}{\text{Refused TSR} + \text{Confirmed TSR count}} * 100$$

4. **Transmission Reservation Utilization (TRU) 75 and 90 Count metrics for interface**: These metrics count the number of instances where total firm or non-firm reservations on a given interface were greater than 75% or 90%, respectively, of the TTC for that interface.

These OASIS metrics are generally a good indicator of the transmission availability during the reservation time for transmission customers; however, these OASIS metrics should not be taken as an absolute measure of congestion for the following reasons:

1. The real limitation may not come from the posted TTC of an interface, but could be due to internal flowgate(s). It should be noted that, in most cases, TTC used for the interface metrics calculation (e.g., TRU metrics) uses the sum of the tie line capability which may not be the real limiter, as opposed to an overloaded internal flowgate during the transmission operation.
2. Unavailability of transmission (zero ATC/AFC) does not necessarily mean transmission congestion, since a typical transmission system is planned only to accommodate the current level of committed confirmed firm transmission service. In addition, non-firm transmission services are offered from the unused firm capability only on an available basis.
3. In some cases, the availability of transmissions is affected by scheduled or unplanned outages, which might lead to zero ATC during the time of the outage, but may not be reflective of a persistent condition of congestion.

3.2 Utilization Metrics for Scheduled flow and Actual flow

There are significant differences in the way these schedules are determined by different transmission system operators and BAs. Transmission system operators within an RTO or ISO

rely on formal, centralized markets in which the schedules are developed based on competitive offers submitted by generators and loads. Transmission system operators in the non-markets rely on energy tags submitted by customers to develop schedules.

BAs also collect and store actual meter flows at the intertie points between BAs. These data are used to compute the actual flow levels between sub-regions. The metered flows at the BA interfaces generally are metered for each direction (Import (ln) and Export (out)); however, some of the data available from the Bas are net values. In the case of net values, it is assumed that the negative values are imports and the positive values are exports.

The following schedule utilization metrics and actual flow metrics were developed as part of this study.

1. **Utilization (U) 75 and 90 count for the interface**: Separate metrics are calculated for schedule and actual flow. This metric counts the number of instances when total schedule or actual flow on the given interfaces were greater than 75% or 90% of the TTC of that interface.
2. **Scheduled flow count above TTC for the interface**: This metric counts the number of instances when the total scheduled flow on the given interface was above TTC of that interface.

These schedule utilization metrics and actual flow metrics are generally a good indicator of the transmission limitation during actual operation; however, none of the metrics in this report should be taken individually as an absolute measure of limitations. Energy schedules and actual flow on an interface could already be reduced by TLR calls or market dispatch during RT operation. Therefore, schedule and actual flow metrics may not show any limitations, since TLR calls and market re-dispatch could be the reason for the reduced flow and schedule on these interfaces.

3.3 TLR Metrics

Eastern Interconnection uses IDC to manage system overloads. IDC provides the operators ability to monitor certain power system equipment (flowgates) for overloads. When an overload on a flowgate is detected, the operator of the flowgate enacts TLR procedures identified by IDC to reduce the transfer of power through the flowgate. TLRs curtail scheduled transactions in order to modify power flows that would otherwise lead to violations of reliability criteria. These

procedures are typically invoked when there exists a potential for violations of reliability criteria from overscheduling and/or from unplanned outages.

TLRs identify the schedules/e-Tags and the amount of energy that must be curtailed due to transmission constraints during RT operation. There are established protocols that determine how the curtailments are allocated among the various classes of energy transactions (e.g., firm vs. non-firm service).

The following TLR metrics were developed as part of this study:

1. Yearly TLR count.
2. Yearly TLR duration.
3. Yearly Megawatt Hour (MWh) curtailed.
4. Five most limiting flowgates.

TLRs are called on the flowgates to mitigate overloads on the transmission system through reduction of flow on a flowgate. The implementation of this reduction impacts the schedules on an interface or on market flows. Data supplied by IDC furnished the list of all schedules (e-Tags) that were curtailed due to a TLR. Based on the physical path (Point of Receipt [POR]/ Point of Delivery [POD]) of the schedules, the interfaces impacted by the TLR were identified and the above metrics were calculated. This study also developed TLR metrics for the sub-region and identified the five most limiting TLR flowgates.

3.4 Market Metric

Transmission congestion in a market is managed mostly by market re-dispatch instead of relying on schedule (e-Tag) reduction as part of the TLR procedure to alleviate congestion. The market operator will call for market re-dispatch by binding a constraint in the market when there are one or more potential or actual operating security limit violations.

When the binding constraint is on Jointly Controlled Market (JCM) flowgates, market re-dispatch and settlement are managed using the coordination agreement between the RTOs. The coordination agreement allocates the firm market Flow Entitlements for each RTO. These firm Flow Entitlements for the RTOs are calculated based on historical usage. Market-to-Market (MTM) payments are calculated between coordinated RTOs based on over or under use of each

RTO's firm market Flow Entitlements. The coordinated non-monitoring RTO[1] pays for the generation re-dispatch if that RTO has exceeded its firm Flow Entitlements. Market flow impact above historical usage can be used as an indicator of congestion similar to TLR metrics.

The metric developed in this study provides some indication of transmission limitations or congestion experienced on the Eastern Interconnection interfaces and sub-regions. Congestion can be physical and/or financial. The study metrics like OASIS metrics and TLR metric are to be considered as an indicator of physical congestion or transmission limitations while market metrics are a better indicator of a financial congestion. It should be also noted that metrics like transmission reservation utilization or schedules utilization metrics may not be any indicator of any physical congestion or financial congestion, however, they could be a good indicator of level of transmission utilization on an interface. Binding constraints and associated congestion cost data were collected for the calculation of the market metrics. The study calculated market metrics from only the RT market as Day-Ahead Market (DAM) values are not realistic due to the impact of virtual bidding. Virtual bidding is a market mechanism that allows market participants to purchase (or sell) power in the DAM with the explicit requirement that they sell (or buy back) the same amount of power in the RT Market. It is a financial transaction which is available to market participants in DAM, and does not require physical generation or load. It should be noted that for example, PJM only models about a quarter of all transmission constraints in the DA market.

This study used BAL congestion costs from the RT market which is balancing congestion cost paid due to deviations from the DA market. The total congestion cost in a market is the sum of the DA congestion cost and balancing congestion cost in RT. Since this study is focused on the RT congestion and limitation, balancing congestion charges will provide a good measure of financial congestion encountered in the market. It should be noted that without the DA congestion cost, market metrics calculated in this study cannot be considered as total financial congestion for a market.

[1] In MTM coordination, one RTO is the Monitoring Regional Transmission Organization (MRTO) of a particular flowgate with the other RTO is the Non-Monitoring Regional Transmission Organization (NMRTO). When that flowgate needs relief, the MRTO first re-dispatches to relieve that flowgate, then the MRTO coordinates with the NMRTO to provide additional relief. Once the NMRTO provides additional relief, then the MRTO will re-dispatch again to turn off high Locational Marginal Price (LMP) units.

The congestion cost of a binding transmission constraint on an interface is considered an indicator of congestion on that interface; higher cost indicates a higher congestion level.

Using all the hourly RT binding constraints and congestion costs provided, the study developed the following two metrics.

1. Sub-regional market metric based on binding count and RT congestion cost.
2. Sub-regional market flow metric based on binding count and market flow settlement cost.

3.5 Market Metric Based on Binding Count and RT Congestion Cost

The study developed sub-regional market metrics for PJM, SPP, New York Independent System Operator, Inc. (NYISO), and ISO New England Inc. (ISONE). No market metrics were developed for MISO since MISO did not include RT congestion cost in their data submittal. BAL_CONG values were used for RT congestion cost. The study only considered binding constraints which were owned by the sub-region being studied. For each hour, binding constraints with the same monitored elements were grouped and congestion costs were summed. The absolute value of the congestion cost was used if the congestion cost was negative. For each binding constraint, the hourly RT congestion cost was summed to calculate the yearly cost. The five most limiting binding constraints were identified based on the yearly RT congestion cost. In addition, the five most limiting binding constraints were identified based on the binding count.

3.6 Market Flow Metric Based on Binding Count and Market Flow Settlement Cost

The study developed sub-regional market flow metrics for PJM, SPP, and MISO. No market flow metrics were developed for NYISO and ISONE since these markets did not participate in the market flow settlement. Market flow settlement cost values were used for this calculation instead of the full RT congestion cost. The study only considered binding constraints which were owned by the sub-region being studied and had market flow settlement costs. For each hour, binding constraints with the same monitored elements were grouped and the congestion costs were summed. The absolute value of the market flow settlement cost was used if the congestion cost was negative. For each binding constraint, the hourly market flow settlement cost was summed to calculate the yearly cost. The five most limiting binding constraints were identified based on the yearly market flow settlement cost. In addition, the five most limiting binding constraints were identified based on the binding count if there was a settlement cost associated with the binding constraint.

4. Data Sources

This section provides more details on data sources, assumptions, and exceptions used in this study.

4.1 OASIS Data Collection

OASIS data were collected from respective OASIS archives. With regards to each BA, export data was collected off of the BA's OASIS node, while import data was collected from each neighboring BA's OASIS node. In some cases, where OASIS data were not available on OASIS, the OASIS operator was contacted to provide the data in an electronic format.

Hourly firm and non-firm ATC, TTC, and Transmission reservation data were collected from publicly available OASIS sites.

In most cases, OASIS data from source side of interface were used to calculate OASIS metrics. For example, for the MISO-SOCO interface data from MISO OASIS was used for the metric calculation. If data were not available from the source side of the OASIS, then data were taken from the sink OASIS. Table A in Appendix A-1 provide more details of OASIS data sources and other additional assumptions that is used in OASIS metric calculation for each interfaces. One point worth noting is that source and sink TSR data from either side of the same interface may or may not match. For example for MISO-SOCO, TSR denial count due to lack of ATC is taken from the MISO OASIS (source side) may not match with denial count in SOCO OASIS (sink side).

Associated Electric Cooperative, Inc. (AECI), PJM, and NYISO provided OASIS data directly for this study. For AECI, ATC data was not available from OASIS, so metrics related to these were not generated. NYISO does not post reservation data on their website, so metrics related to reservations were not developed for NYISO. For interfaces with Louisville Gas and Electric (LGEE) as the source, the TTC value for LGEE interfaces with PJM, MISO, and Tennessee Valley Authority (TVA) was collected from the ATC Initialization Impact report posted on LGEE's OASIS. FOR AECI, TTC value was provided by AECI based on their transmission planning models. For SPP, OASIS data were available only for some sub-paths with MISO; therefore, OASIS data for SPP to MISO were taken from MISO's OASIS. As requested by TVA, this study assumed the following for the TVA-MISO interface.

- Until May 26, 2015 the TVA-MISO interface consisted of TVA-MISO and TVA-EES paths posted on the TVA OASIS.

- Starting from May 27, 2015 the TVA-MISO interface consists of TVA-MISO.N and TVA-MISO.S paths posted on the TVA OASIS.

There were some paths for which TTC data were not available from both sided of the OASIS; these paths were not considered for OASIS metric calculations except the zero ATC count metrics. More details are provided in Appendix A-1.

PJM, MISO, SPP, NYISO, LGEE, and TVA provided the 15 most limiting flowgates for the sub-region. However, AFC data are not readily available in a machine-readable format on OASIS archives for these flowgates. Therefore, the study did not identify the five most limiting AFC flowgates from the sub-regions' list except for PJM and NYISO. The limiting flowgates list from the sub-regions is provided in Appendix C. The PJM and NYISO sub-regions provided AFC data directly for the study. PJM provided the ATC value, Dfax, and associated limiting flowgates to calculate AFC.

Non-RTO Midwest is currently being considered in this study as a group of entities (see Appendix A1) as defined by EIPC. In the future studies, a consultation with DOE will be taken to consider whether to break down the entities in the Non-RTO Midwest group and create metrics and graphs for the individual entities.

Western Area Power Administration, Upper Great Plains East (WAUE) BA Area became part of the SPP sub-region starting October 2015. WAUE was considered part of MAPP-US for the first nine months of 2015 and part of SPP for the last three months of 2015.

The EIPC diagram shows a single interface between PJM and MISO sub-regions. This interface has multiple electrical connections with each connection limited by the installed transfer capability; however, the algebraic sum of these connections gives an unrealistically high total rating for transfer. There are other operational and electrical considerations that make this transfer limit smaller. PJM advised that the limitations on this interface should be grouped into three relatively independent sub-paths. The PJM to MISO interface sub-paths were defined based on electrically similar connectivity to the PJM to MISO system. PJM does not apply path groupings when calculating ATC or TTC along the PJM-MISO interface as it only monitors flowgates for operation limitations; however, for the purposes of this study, the path groupings were used to represent the total interface capability.

4.2 Schedule Data (e-Tags)

Schedule (e-Tag) data were collected from the OATI webTag system with permission from the participants. Interface schedules are determined based on the POR/POD combination for the interface. Appendix A-2 lists out the POR and POD combinations used to determine schedules.

PJM and NYISO were not able to give permission to use e-Tag for developing these schedules for the interfaces originating from their sub-region. PJM posts the scheduled flows on their website, and the study used these posted schedules to calculate the flow metrics. NYISO posts TTC and ATC information which was used to back calculate schedules based on the formula provided by NYISO.

4.3 Actual Flow Data (Metered Data)

BAs meter the flows with neighboring BAs. These actual flows (metered) on the BA-to-BA interconnections are monitored and recorded for inadvertent accounting. The study aggregated the tie lines that make up an interface. Appendix A-1 provides the data source, assumptions, and sub-paths used to determine actual flows on interfaces. Actual metered data were provided by the transmission owners for tie lines monitored by them. The actual flow for the PJM interfaces was collected from the PJM website. Actual flow for NYISO interfaces was collected from the NYISO website. TVA was not able to provide the data as TVA does not store historical data going back to 2015.

The actual flow metrics are based on the direction of the flow from source BA to sink BA. Source BA data were used to calculate these metrics. If data were not available from the source BA, the sink BA data were used.

Some sub-regions, such as AECI, MISO, Virginia-Carolinas Area (VACAR), and non-RTOs, provided directional actual flow values. Other sub-regions, such as PJM, ISONE, Southern Company Services, Inc. (SOCO), SPP, and NYISO, provided net actual flows. Appendix B provides a few examples of actual flow utilization when actual flows were provided in either net or directional form.

4.4 TLR Data Collection (IDC)

IDC data for TLR events were obtained from the IDC database. Eastern Interconnect Data Sharing Network, Inc. (EIDSN) maintains TLR information. TLR data were obtained from OATI's data repository with permission from individual sub-regions.

The following data were used for the TLR metric calculations for interfaces and the sub-region:

- Flowgate that was constrained so a TLR was issued.
- Time duration of TLR.
- MWH curtailed for a TLR.
- Level (priority) of TLR (0-7).

The non-firm schedule curtailments were based on TLR levels 0-6 and the firm curtailments were calculated based on TLR level 7. PJM was unable to give permission to use the IDC database. Therefore, for PJM, data on the North American Electric Reliability Corporation (NERC) public website were used. It should be noted that PJM TLR metrics are based on the first seven months of 2015, as PJM data were only available for this timeframe.

4.5 Market Data

PJM, MISO, SPP, PJM, NYISO, and ISONE provided the market data for the study. The market data provided include:

1. Time of the binding transmission constraint.
2. Binding constraint ID and constraint name.
3. Flowgate ID of the flowgates associated with the binding constraint.
4. RT Congestion cost associated with the binding constraints (from PJM, SPP, PJM, NYISO, and ISONE).
5. Market flow settlement cost (from MISO, PJM, and SPP).
6. Flowgate name.

The binding constraint names used in the metric results are the ones which were provided and preferred by market participants as per their constraint naming conventions.

5. Results

This section provides the metrics calculated for the interfaces and sub-region. The data are arranged as entity/sub-region results containing both interface and sub-region data if possible. Data used to create these metrics are from the source entity. Metrics and graphs developed for each sub-region and their interfaces are presented in a sequential flow. If a particular data set is not available for a sub-region or an interface, that metric or graph is not developed and not listed in results. First, all the metrics created for a sub-region are listed out: Zero AFC metric, market based metric, market flow metric, and TLR metric. After that, metrics and graph created for the interfaces are listed out; Transmission Service Request metric, Transmission Reservation Utilization metric, Zero ATC metric, graphs for Zero ATC count, Schedule Utilization metric, Actual flow Utilization metric, TLR metric, and Interface Data Analysis Summary graphs. After all these graphs and metric are listed out, at the end of each entity result, a summary is presented to list all the metrics created for sub-region and their interfaces. A summary also identifies the most limiting result for each metric.

5.1 PJM

5.1.1 Sub-Region Metrics

5.1.1.1 Zero AFC Metrics

PJM provided the ATC value for each path. In addition to ATC value, PJM provided Distribution Factor (Dfax) for each path for all flowgates. Each flowgate AFC was back calculated by multiplying ATC and Dfax. The study ranked the flowgates based on the total number of zero AFC counts for the flowgate. The top five flowgates based on this ranking are listed in Table 5.1-1.

PJM	Firm		Non-Firm	
	Flowgate	Count	Flowgate	Count
Top Five Limiting Flowgate	LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR	2496	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	176
	155 Nelson 345/138kV TR82 l/o Byron-LeeCo 345kV	2424	17714-Hegewisch 138 l/o Burnham-Sheffield 345	103
	Breed-Wheatland 345 (flo) Jefferson-Rockport 765	2160	Breed-Wheatland 345 (flo) Jefferson-Rockport 765	88
	124 Maryland-11902 138kV l/o Byron-LeeCo 345kV	2064	155 Nelson 345/138kV TR82 l/o Byron-LeeCo 345kV	55
	BROKAW-80PONTIAC 345 (FLO) BLUE MOUND-80PONTIAC 345	1176	Kyger Creek-SPORNAEP ckt2 345	50

Table 5.1-1: PJM Top Five Limiting Flowgate

5.1.1.2 Market Metric Based on Binding Count and RT Congestion Cost

PJM provided the hourly data for all binding constraints including binding constraint name, flowgate information, and the associated congestion cost for the hour. The total market cost for the whole year was not available for PJM, therefore the metric calculation was limited to total congestion cost for the binding constraints.

This study developed sub-regional market metrics for PJM and identified the five most limiting flowgates based on the market binding counts.

To calculate the cost associated with these constraints, (BAL_CONG) congestion cost was used.

For each hour, binding constraints with the same monitored elements were grouped and the congestion costs summed. Only binding constraints owned by PJM sub-region were identified. The absolute value of congestion cost was used if the congestion cost was negative. All unique constraints (based on monitored element) for that year were listed out, and their corresponding yearly counts were calculated.

Using congestion cost, the respective yearly cost for the constraint's elements was calculated by adding up all costs encountered for the year. Each constraint was assigned a total yearly congestion cost.

The results from the Market metrics for the PJM sub-region are provided in Table 5.1-2a and Table 5.1-2b.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours
1	Laporte-Michigan City 138 1 (MISO)	300	21.73%
2	Burnham-Munster 345 (COMED-NIPS)	215	15.57%
3	Dixon-McGirr Road 10714 138 (COMED)	171	12.39%
4	Crete-St. John 345 (COMED-MISO)	111	08.04%
5	Nelson 345/138 TR82 (COMED)	100	04.63%

Table 5.1-2a: Five Most Limiting Binding Constraints in the PJM Sub-Region (by Count)

Binding constraints Ranking	Binding Constraints Name	Congestion Cost ($M)
1	Dixon-McGirr Road 10714 138 (COMED)	6.1

Binding constraints Ranking	Binding Constraints Name	Congestion Cost ($M)
2	Laporte-Michigan City 138 1 (MISO)	4.6
3	H471-Quad Cities 0404 345 (COMED)	3.6
4	Byron-Cherry Valley 0622 6 345 (COMED)	2.8
5	Byron-Wempletown 0624 345 (COMED)	2.2

Table 5.1-2b: Five Most Limiting Binding Constraints in the PJM Sub-Region (by Cost)

5.1.1.3 Market Flow Metric based on Binding Count and Market Flow Settlement Cost

Market flow metrics were developed that identify the five most limiting flowgates by their binding count and congestion cost.

To calculate the market flow cost associated with these constraints, MTM settlement costs (MTM-credit/payment) were used. The absolute value of the MTM cost was used if the MTM cost was negative. For each hour, binding constraints with the same monitored elements were grouped and congestion costs summed. Only binding constraints owned by the PJM sub-region were identified if there was a settlement cost associated with the binding constraint.

All unique constraints (based on a monitored element) for the year were listed out, and their corresponding yearly counts were calculated.

Each constraint was assigned a total yearly congestion cost.

The results from the market flow metrics for PJM are provided in Table 5.1-3a and Table 5.1-3b.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours
1	Laporte-Michigan City 138 1 (MISO)	319	21.95%
2	Burnham-Munster 345 (COMED-NIPS)	216	14.86%
3	Dixon-McGirr Road 10714 138 (COMED)	166	11.42%
4	Crete-St. John 345 (COMED-MISO)	112	07.70%
5	Maryland-11902 4 138 (COMED)	108	07.43%

Table 5.1-3a: Five Most Limiting PJM-Owned Binding Constraints to the Market Flow Impacts (by Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)
1	H471-Quad Cities 0404 345 (COMED)	2.4
2	Laporte-Michigan City 138 1 (MISO)	2.1
3	Maryland-11902 4 138 (COMED)	1.6
4	Dixon-McGirr Road 10714 138 (COMED)	1.5
5	Nelson-Cordova 15503 345 (COMED)	1.1

Table 5.1-3b: Five Most Limiting PJM binding Constraints to the Market Flow Impacts (by Cost)

5.1.1.4 TLR Metrics

This study also developed TLR metrics for the PJM sub-region and identified the five most limiting TLR flowgates based on the TRL counts. As discussed in section 4.4, TLR data on the NERC public website were used for the PJM TLR metric calculation. It should be noted that PJM TLR metrics are based on the first seven months of 2015, as PJM data were available only for this timeframe. The results from the TLR metrics for the PJM sub-region are provided in Table 5.1-4a and Table 5.1-4b.

Sub-Region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
PJM	0	0	0	254	59804	23

Table 5.1-4a: TLR Metrics for the PJM Sub-Region

Sub-Region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
PJM	None	0	0	310 - Person-Halifax 230 kV line l/o Wake-Heritage 500 kV	8	39218
				20793 - Greenville-Everetts 230 kV l/O Bath County-Valley 500 kV Line	4	3045
				20817 - Greenville-Everetts 230 kV l/o Edgecombe-Rocky Mount 230 kV	3	1926
				1704 - Person-Halifax 230 kV line	2	6419
				1707 - WAKE-CARSON 500	1	4985

Table 5.1-4b: Top Five TLR Limiting Flowgates (Count Based) for the PJM Sub-region

5.1.2 PJM Interface Metrics

The interface between PJM and MISO, due to being spread over a large geographical and electrical area, was separated into the following three electrical groups suggested by PJM for this analysis:

Group 1: PJM > MECS.
Group 2: PJM > ALTE, PJM > ALTW, PJM > MEC, PJM > WEC.
Group 3: PJM > NIPS, PJM > AMIL, PJM > IPL, PJM > CIN.

The above subgroup approach was used rather than adding up all of the segments for a single path to get the final hourly ATC and TTC value for the PJM to MISO interface. An average value was computed for each group of interties and then the values were added together to get a final hourly value for the PJM to MISO interface. Consider the following example of how TTC was calculated for PJM to MISO.

Group	Path	Historical TTC	Group Average TTC
1	PJM > MECS	3000	3000
2	PJM > ALTE	4500	2550
	PJM > ALTW	2500	
	PJM > MEC	2200	
	PJM > WEC	1000	
3	PJM > NIPS	5700	3850
	PJM > AMIL	4800	
	PJM > IPL	2200	
	PJM > CIN	2700	
Interface TTC			9400

Table 5.1-5: Interface TTC

This grouping was only done only for the PJM to MISO interface. For other PJM's interfaces, which may not have as many sub-paths, these sub-paths were added up to get a final value for each particular interface.

5.1.2.1 Transmission Service Request Metric

These metrics were based on the total number of firm and non-firm TSRs counts for reservations confirmed and refused on the interfaces. The study also calculated firm and non-firm

reservation Megawatt (MW) confirmed and MW refused on the interfaces. The results from the TSR metric for the PJM interfaces are provided in Table 5.1-6a through 5.1-6d.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
PJM >MISO	323	26	7.45
MISO >PJM	293	1708	85.36
PJM > NYISO	49	1	2
NYISO > PJM	N/A	N/A	N/A
PJM > VACAR	1	0	0
VACAR > PJM	218	10	4.38
PJM > TVA	29	13	30.9
TVA > PJM	210	1660	88.77
PJM > Non RTO Midwest	16	9	36
Non RTO Midwest > PJM	6	0	0

Table 5.1-6a: Firm Confirmed and Refused TSR Count

Interface	Non-Firm Confirmed TSR Count	Non-Firm Refused TSR Count	% Refusal
PJM > MISO	10748	10	0.09
MISO > PJM	5508	3390	37.5
PJM > NYISO	5462	172	3.05
NYISO > PJM	N/A	N/A	N/A
PJM > VACAR	136	0	0
VACAR > PJM	3256	52	1.57
PJM > TVA	317	0	0
TVA > PJM	1038	733	41.39
PJM > Non RTO Midwest	326	4	1.21
Non RTO Midwest > PJM	2093	109	4.95

Table 5.1-6b: Non-Firm Confirmed and Refused TSR Count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
PJM > MISO	1621200	N/A	N/A
MISO > PJM	14395010	178400498	92.53
PJM > NYISO	21428064	NA	NA
NYISO > PJM	N/A	NA	NA

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
PJM > VACAR	3301824	NA	NA
VACAR > PJM	858524	451776	34.48
PJM > TVA	9453936	N/A	N/A
TVA > PJM	3543819	145767380	97.63
PJM > Non RTO Midwest	7273704	N/A	N/A
Non RTO Midwest > PJM	1660997	0	0.00

Table 5.1-6c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
PJM > MISO	8557095	NA	NA
MISO > PJM	1277642	2440871	65.64
PJM > NYISO	17024774	NA	NA
NYISO > PJM	NA	NA	NA
PJM > VACAR	1304112	NA	NA
VACAR > PJM	1238917	149088	10.74
PJM > TVA	195697	NA	NA
TVA > PJM	648031	1320049	67.07
PJM > Non RTO Midwest	28858	NA	NA
Non RTO Midwest > PJM	250979	10205	3.91

Table 5.1-6d: Non-Firm Confirmed and Refused Reservation MWh

5.1.2.2 Transmission Reservation Utilization Metric

The TSRs are made using a POR and POD on the path being reserved for scheduling. The study interfaces are identified by the POR/POD as listed in Appendix A. In calculating the reservation utilization metrics, care was taken to use only reservations with POR/POD matching interface paths to avoid any double counting of the reservations. This metric counts the number of hours for which the reserved MWh is greater than the 75% and 90% on the TTC.

The results from Transmission Service Utilization Metric for the PJM interfaces are provided in Table 5.1-7a and 5.1-7b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
PJM > MISO	0	167
MISO > PJM	0	0
PJM > NYISO	0	8
NYISO > PJM	N/A	N/A
PJM > VACAR	0	0
VACAR > PJM	0	0
PJM > TVA	0	28
TVA > PJM	0	0
PJM > Non RTO Midwest	0	0
Non RTO Midwest > PJM	0	0

Table 5.1-7a: TRU75 for Firm and Non-Firm Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
PJM > MISO	0	10
MISO > PJM	0	0
PJM > NYISO	0	5
NYISO > PJM	N/A	N/A
PJM > VACAR	0	0
VACAR > PJM	0	0
PJM > TVA	0	21
TVA > PJM	0	0
PJM > Non RTO Midwest	0	0
Non RTO Midwest > PJM	0	0

Table 5.1-7b: TRU90 for firm and non-firm reservation

5.1.2.3 Zero ATC Metrics

For the PJM > MISO interface, the approach described in the pilot study was used. An hourly ATC of zero indicates that there was no ATC available for that hour. The ATC metrics provide the total number of hours for which this ATC was zero during the year. In some cases, firm ATC values are posted as a single daily value instead of hourly values. These daily values were converted to hourly values by assigning that same daily value to each hour of the day.

The results from ATC Metric for PJM interfaces are provided in Table 5.1-8a.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
PJM > MISO	0	0
MISO > PJM	7480	2359
PJM > NYISO	2136	2062
NYISO > PJM	15	15
PJM > VACAR	576	54
VACAR > PJM	35	8
PJM > TVA	3384	270
TVA > PJM	8687	228
PJM > Non RTO Midwest	0	24
Non RTO Midwest > PJM	828	221

Table 5.1-8a: PJM Zero ATC Count

The top five flowgates for Zero ATC for the PJM interfaces are listed below.

Top 5 limiting flowgate	Firm		Non-Firm	
	Flowgate	Count	Flowgate	Count
PJM-MISO	LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR	2496	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	176
	155 Nelson 345/138kV TR82 l/o Byron-LeeCo 345kV	2424	17714-Hegewisch 138 l/o Burnham-Sheffield 345	103
	Breed-Wheatland 345 (flo) Jefferson-Rockport 765	2160	Breed-Wheatland 345 (flo) Jefferson-Rockport 765	88
	124 Maryland-11902 138kV l/o Byron-LeeCo 345kV	2064	155 Nelson 345/138kV TR82 l/o Byron-LeeCo 345kV	55
	BROKAW-80PONTIAC 345 (FLO) BLUE MOUND-80PONTIAC 345	1176	Kyger Creek-SPORNAEP ckt2 345	50
PJM-TVA	St Louis South Interface	465	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	131
	Buckner-Middletown 345 (flo) Trimble Co-Middletown 345	418	PJM Southern Reactive Interface	79
	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	313	St Louis South Interface	29
	PJM Southern Reactive Interface	181	AEP-DOM Interface l/o Bedington-Black Oak 500kV	16
	AEP-DOM Interface l/o Cloverdale 765/345 kV xfmr	136	W Mt Vernon-E W Frankfort 345 (flo) St Francois-Lutesville 345	4
PJM-Non RTO Midwest	None		Wheatland-Petersburg 345 l/o Rockport-Jefferson 765	75
			Bush-Lafayette 138 kV l/o Westwood-Concord SE 138 kV	7

Top 5 limiting flowgate	Firm		Non-Firm	
	Flowgate	Count	Flowgate	Count
			Prairie State-W Mt Vernon 345 kV l/o Coffeen-Roxford 345 kV	5
			Lafaysou-Concordj 138 l/o Cayuga3-Eugene 345	3
			Bushcin-08Lafyte 138 l/o Cayuga3-Eugene 345	2
PJM-VACAR	SHAWNEE 345/500 KV XFMR (FLO) DELL-SAN SOUCI 500 KV	2042	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	298
	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	972	5004/5005 Interface l/o Conemaugh-Hunterstown 500	176
	SHAWNEE - MARSHALL 500KV (FLO) SHELBY - SAN SOUCI 500KV	945	PJM Southern Reactive Interface	154
	6HAL-PERS 230 6CAR-6CLV 500	759	Blackoak-Bedington 500 (flo) Mt. Storm-Doubs 500	99
	6ASHVLE230-3ASHV NTIE 1 6ASHVLE230-3ASHV STIE 1	705	Kyger Creek-SPORNAEP ckt2 345	99
PJM-NYISO	East Towanda-East Sayre 138 (flo) Watercure-Mainesburg 345	884	EAST TOWANDA-EAST SAYRE 115 (FLO) NORTH MESHOPPEN-LENOX 115	815
	Everts Sub-South Troy 115 (flo) Watercure-Mainesburg 345	710	WARREN-FALCONER 115 (FLO) TWO MILE-FARMERS VALLEY 115	783
	WARREN-FALCONER 115 (FLO) TWO MILE-FARMERS VALLEY 115	619	Everts Sub-South Troy 115 (flo) Watercure-Mainesburg 345	339
	Warren-Falconer 115	30	East Towanda-East Sayre 138 (flo) Watercure-Mainesburg 345	71
			Cleveland Interface l/o Perry Unit 1	18

Table 5.1-8b: PJM Top five Flowgates with Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.1-1a through 5.1-1d).

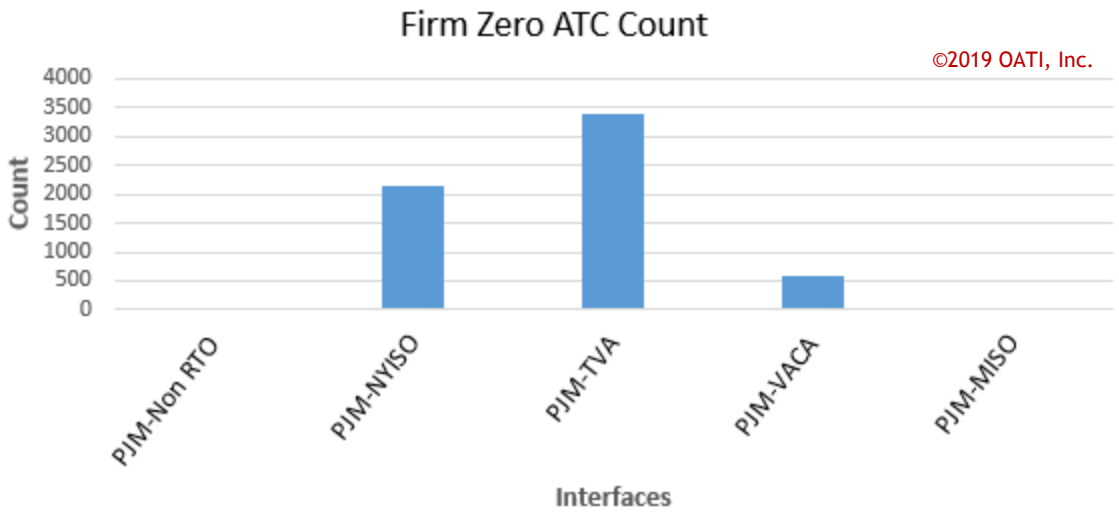


Figure 5.1-1a: Firm Zero ATC Count

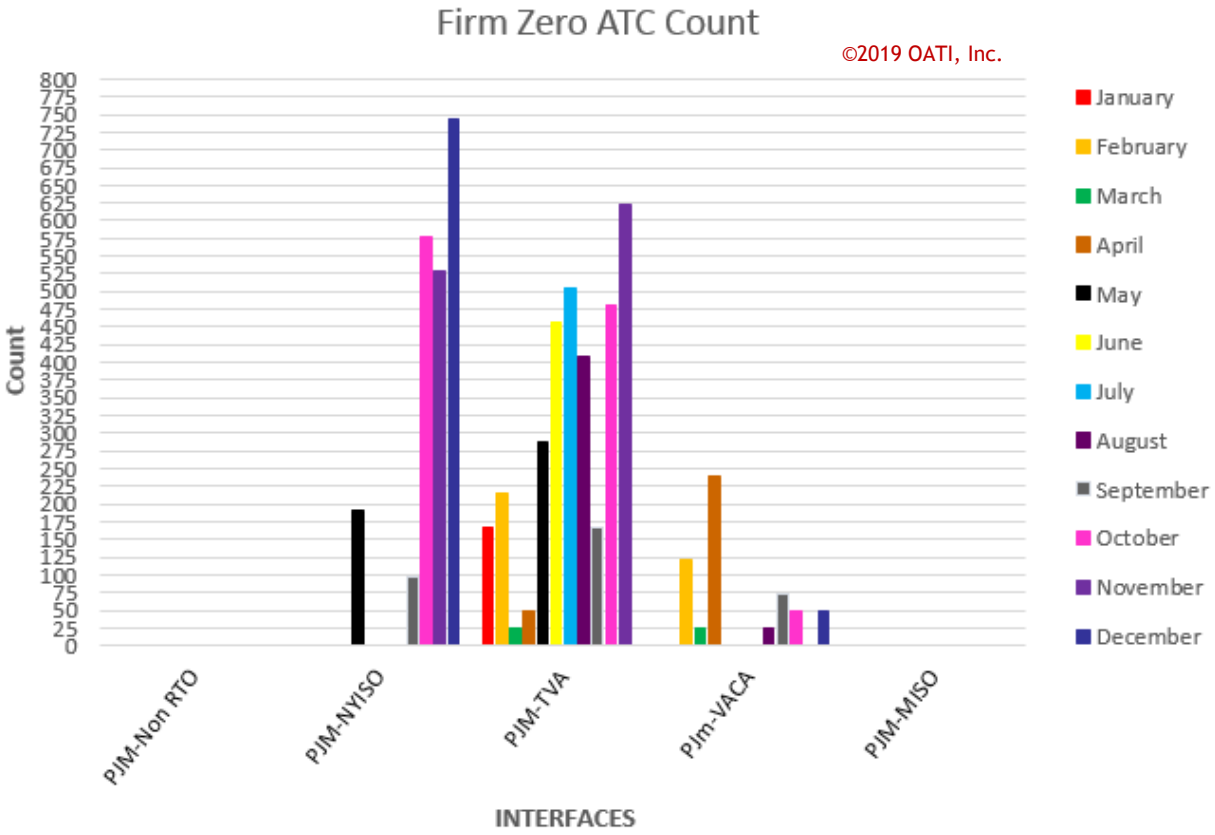


Figure 5.1-1b: Firm Zero ATC Count

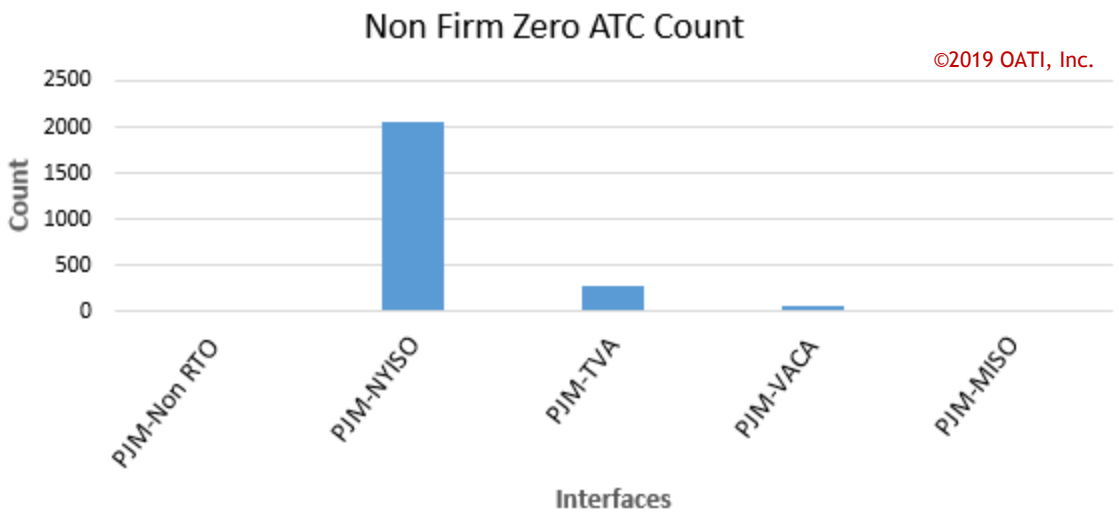


Figure 5.1-1c: Non-Firm Zero ATC Count

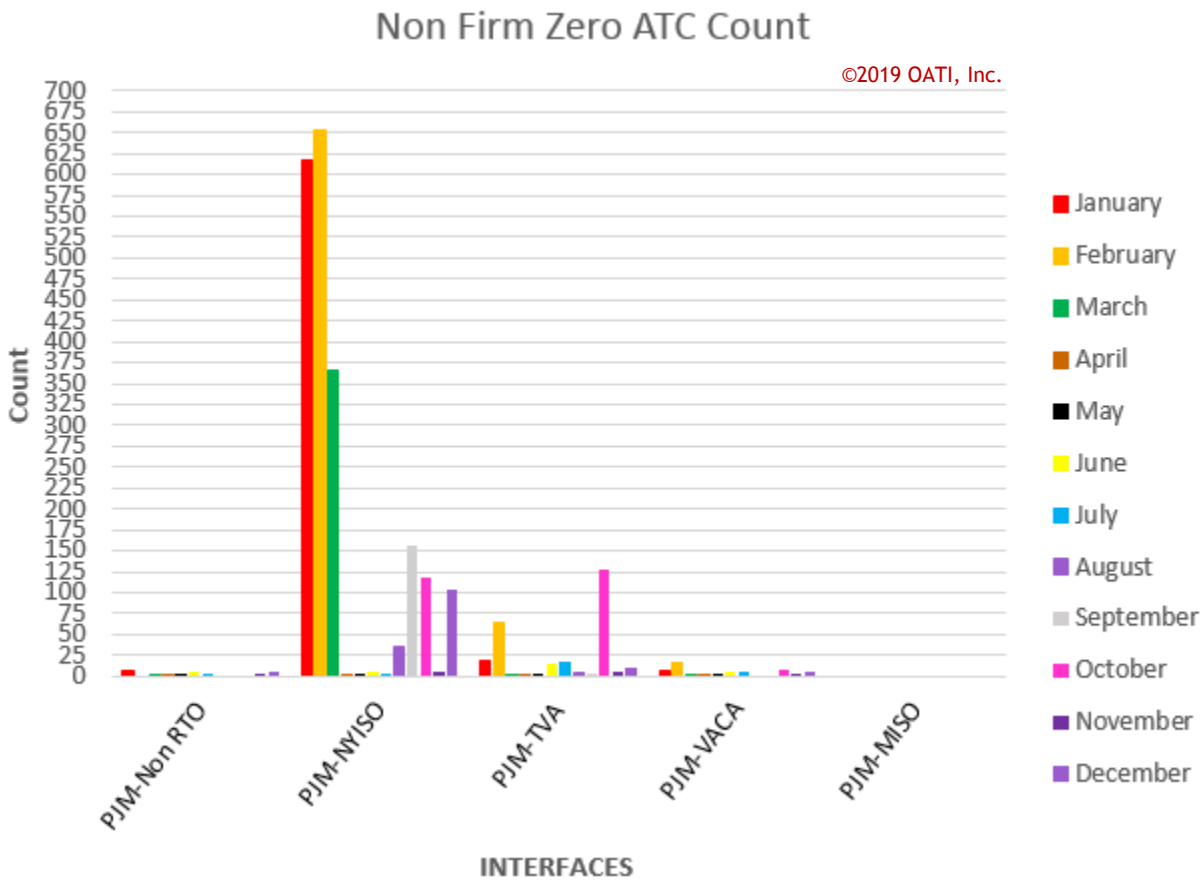


Figure 5.1-1d: Non-Firm Zero ATC Count

From the above ATC graphs, note that the PJM-NYISO and PJM-TVA interfaces have higher zero ATC values for both firm and non-firm than the other interfaces. For the firm ATC, the later part of the year has a higher count while for the non-firm ATC the higher count was in the initial part of the year.

5.1.2.4 Schedule Utilization Metrics and Actual flow Utilization Metrics

Scheduled flow was calculated by summing up all the tags. For PJM > MISO, as tag data were not present, data from the PJM website were used. The data provide the scheduled flow from PJM > MISO entities. Schedules in direction from PJM to MISO were summed up to get the scheduled flow for PJM > MISO.

Actual flow metrics were calculated as explained further in Appendix B. As mentioned before, PJM posts net actual flow data for each of its sub-paths. As PJM has multiple sub-paths for its interfaces, all of those sub-paths were summed to get a net actual flow for a particular hour. For example, the PJM > VACAR interface has three sub-paths; all of these sub-paths' net actual values were added up to get a single net actual flow value for the PJM > VACAR interface.

The results from the schedule utilization metrics and actual flow metrics for the interfaces are provided in Table 5.1-9a and Table 5.1-9b.

Interface	U75 Schedule Count	U90 Schedule Count
PJM > MISO	0	0
MISO > PJM	0	0
PJM > NYISO	35	4
NYISO > PJM	85	29
PJM > VACAR	0	0
VACAR > PJM	294	85
PJM > TVA	0	0
TVA > PJM	869	60
PJM > Non RTO Midwest	0	0
Non RTO Midwest > PJM	0	0

Table 5.1-9a: Scheduled flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
PJM > MISO	0	0
MISO > PJM	0	0
PJM > NYISO	40	14
NYISO > PJM	1010	638
PJM > VACAR	0	0
VACAR > PJM	0	0
PJM > TVA	0	0
TVA > PJM	0	0
PJM > Non RTO Midwest	0	0
Non RTO Midwest > PJM	0	0

Table 5.1-9b: Actual flow Utilization Metric

Metrics for interfaces based on the schedule count above TTC were also developed. The results for the metrics are provided in Table 5.1-9c.

Interface	Schedule Count above TTC
PJM > MISO	0
MISO > PJM	0
PJM > NYISO	1
NYISO > PJM	0
PJM > VACAR	0
VACAR > PJM	0
PJM > TVA	0
TVA > PJM	0
PJM > Non RTO Midwest	0
Non RTO Midwest > PJM	0

Table 5.1-9c: Schedule Count above TTC

5.1.2.5 TLR Metrics

The frequency and duration of TLR actions on particular flowgates were evaluated as a measure of constraints. Frequency indicates how often scheduled transactions were curtailed, and the duration indicates the length of time transactions were curtailed.

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR Metric for the interfaces are provided in Table 5.1-10a and Table 5.1-10b.

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
PJM > MISO	0	0	0	0	0	0
MISO > PJM	0	0	0	643	53016	1180
PJM > NYISO	0	0	0	0	0	0
NYISO > PJM	0	0	0	160	75227	384
PJM > VACAR	0	0	0	245	29804	23
VACAR > PJM	0	0	0	181	22476	350
PJM > TVA	0	0	0	0	0	0
TVA > PJM	0	0	0	162	12074	328
PJM > Non RTO Midwest	0	0	0	0	0	0
Non RTO Midwest > PJM	0	0	0	268	9810	579

Table 5.1-10a: TLR Metrics for Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
PJM > MISO	None	0	0	None	0	0
PJM > NYISO	None	0	0	None	0	0
PJM▫VACAR	None	0	0	310 - Person-Halifax 230 kV line l/o Wake-Heritage 500 kV	8	39218
				20793 - Greenville-Everetts 230 kV l/O Bath County-Valley 500 kV Line	4	3045
				20817 - Greenville-Everetts 230 kV l/o Edgecombe-Rocky Mount 230 kV	3	1926
				1704 - Person-Halifax 230 kV line	2	6419
				1707 - WAKE-CARSON 500	1	4985
PJM > TVA	None	0	0	None	0	0
PJM > Non RTO Midwest	None	0	0	None	0	0

Table 5.1-10b: Top Five Limiting Flowgates (Count Based) for PJM Interfaces

5.1.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all the study interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

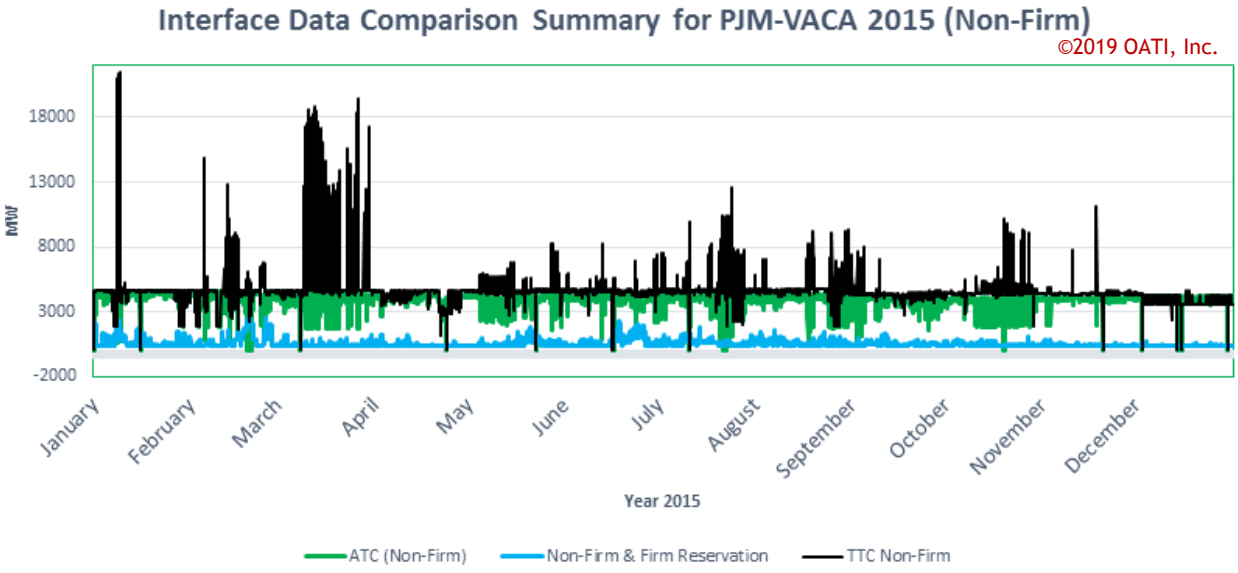


Figure 5.1-2a: Interface Non-Firm OASIS Comparison Summary for PJM > VACAR

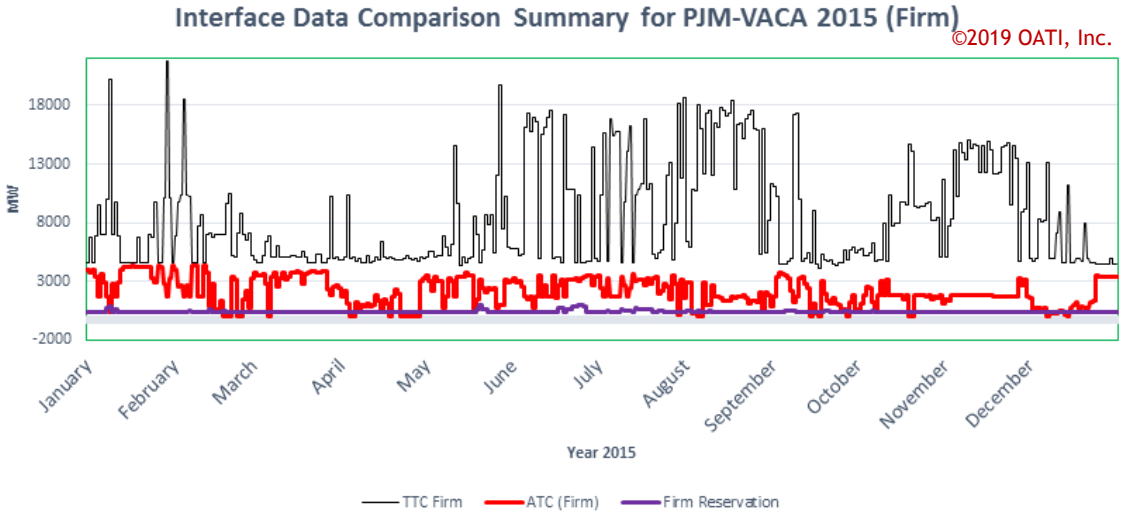


Figure 5.1-2b: Interface Firm OASIS Comparison Summary for PJM > VACAR

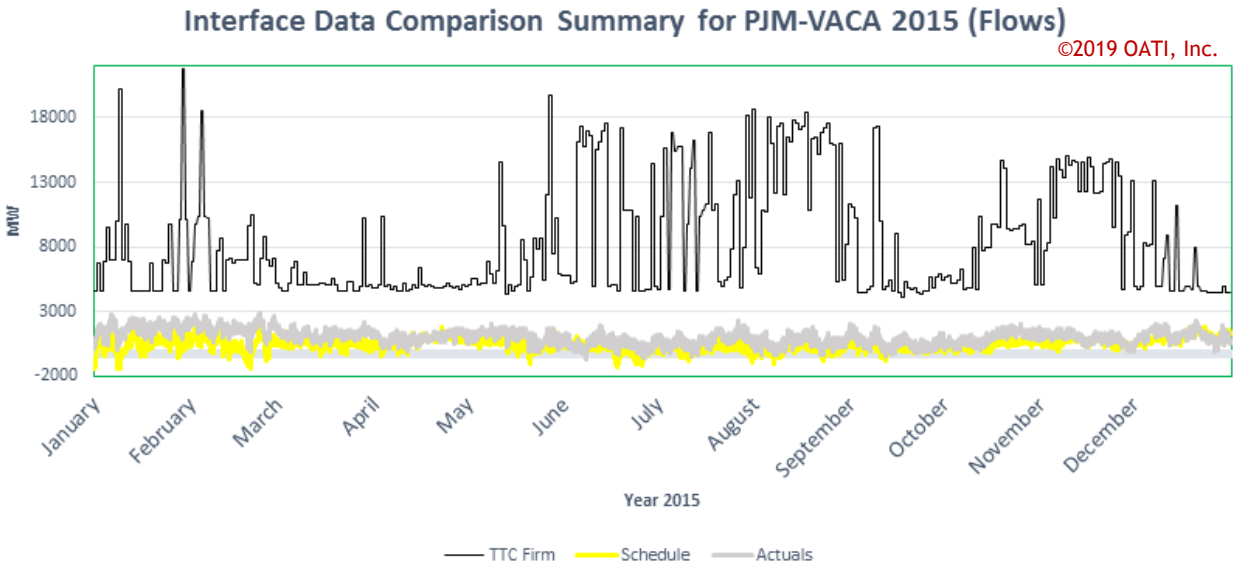


Figure 5.1-2c: Interface Flows Comparison Summary for PJM > VACAR

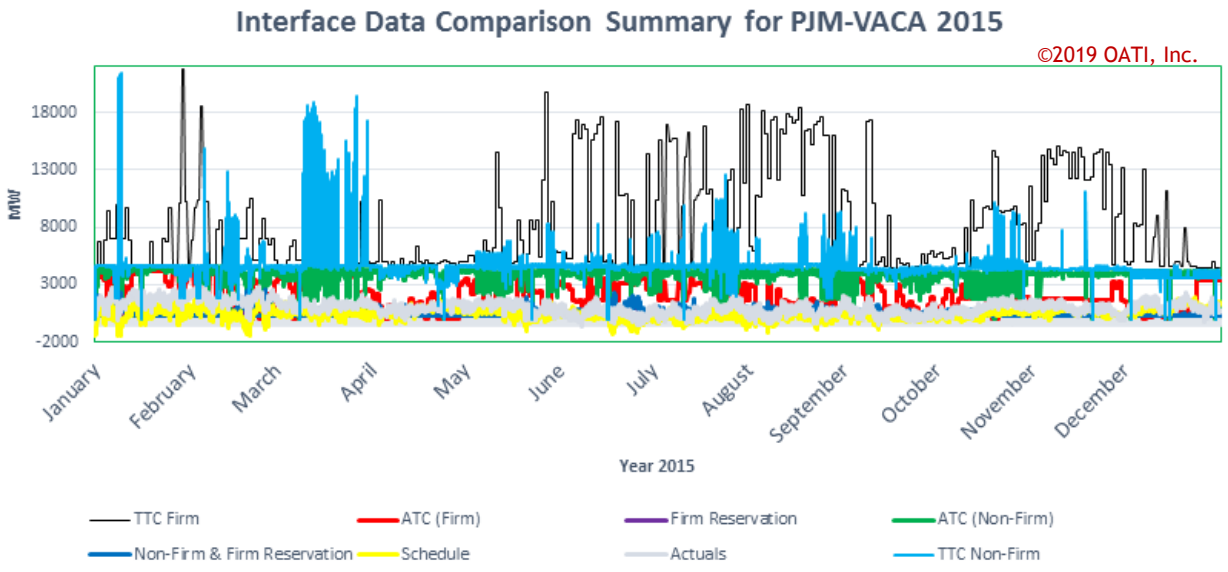


Figure 5.1-2d: Interface Comparison Summary for PJM > VACAR

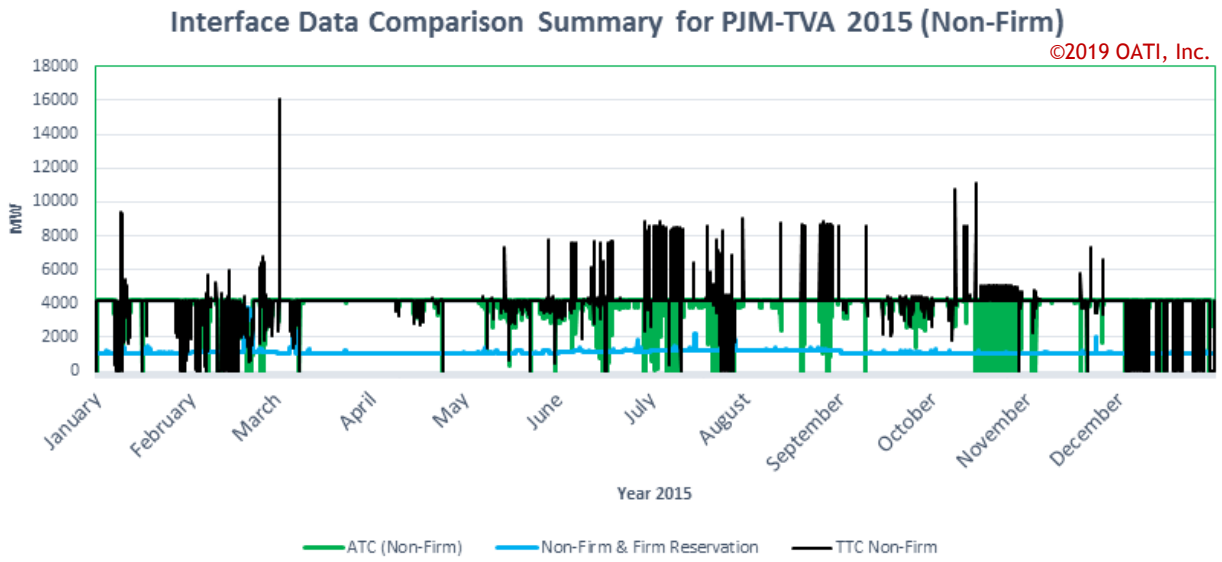


Figure 5.1-2e: Interface Non-Firm OASIS Comparison Summary for PJM > TVA

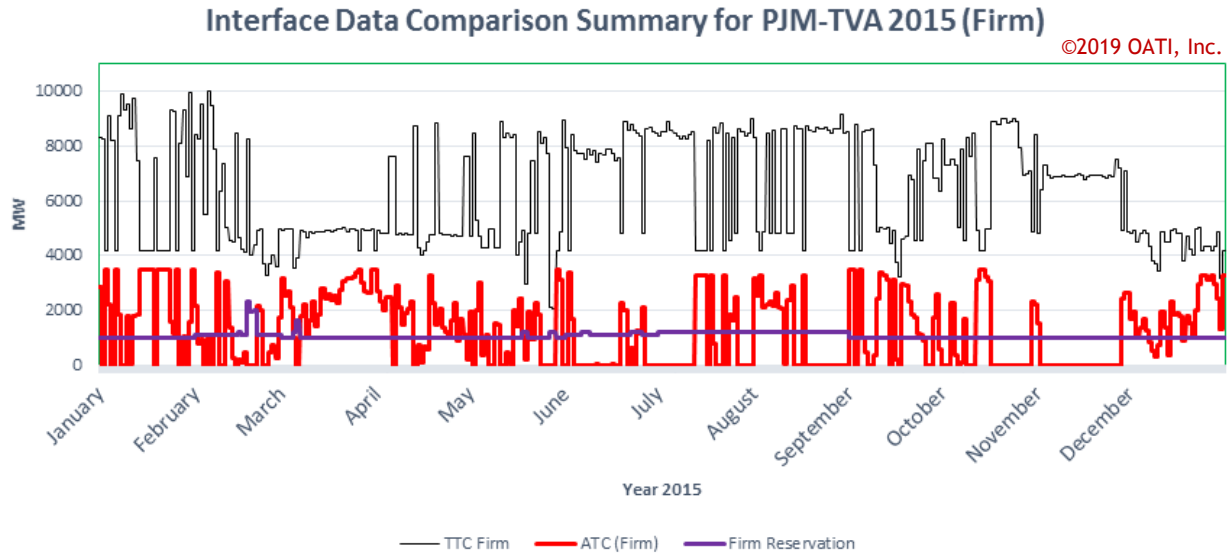


Figure 5.1-2f: Interface Firm OASIS Comparison Summary for PJM > TVA

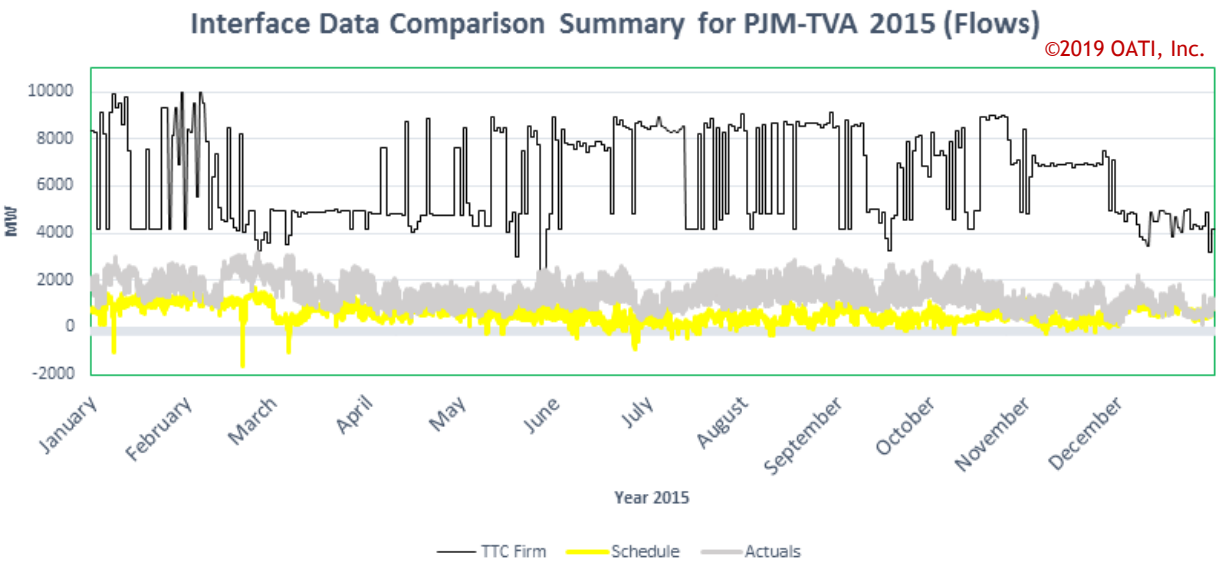


Figure 5.1-2g: Interface Flow Comparison Summary for PJM > TVA

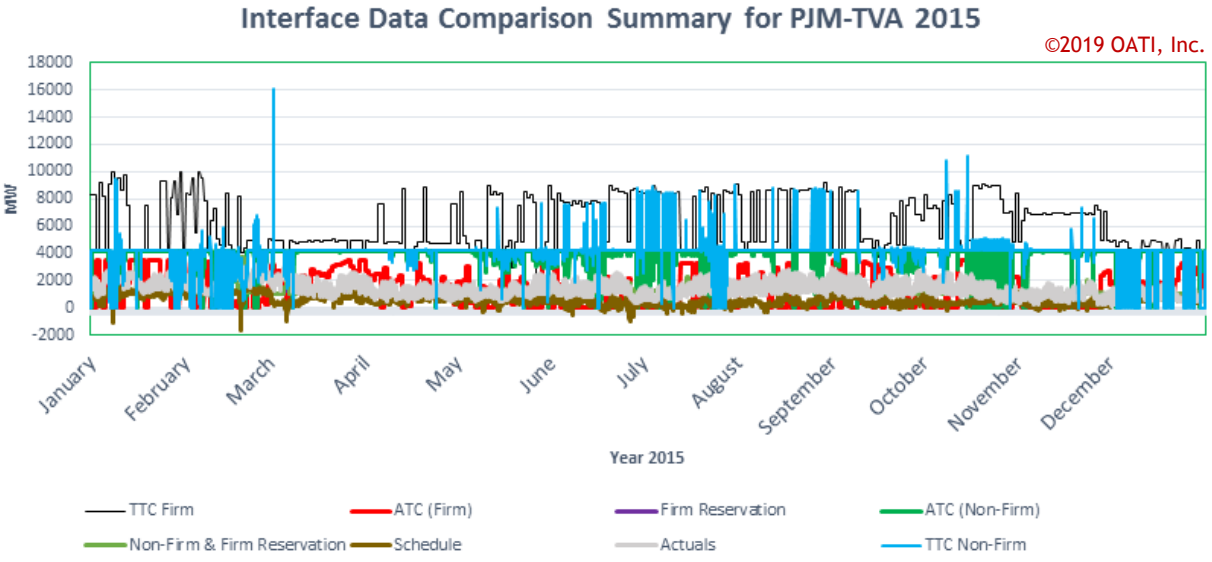


Figure 5.1-2h: Interface Comparison Summary for PJM > TVA

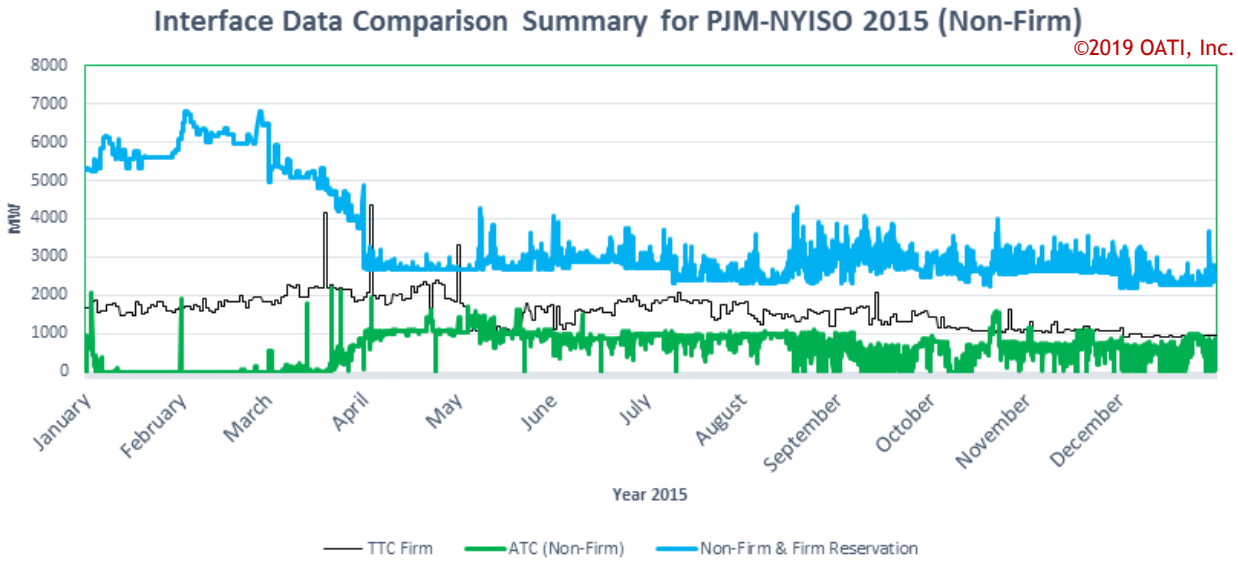


Figure 5.1-2i: Interface Non-Firm OASIS Comparison Summary for PJM > NYISO

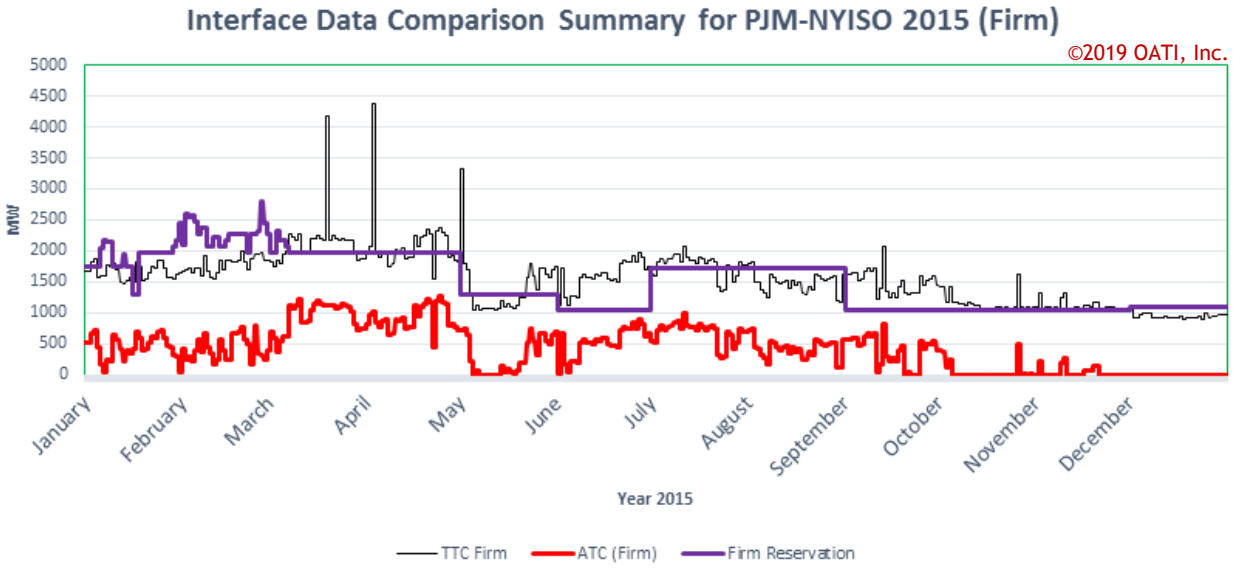


Figure 5.1-2j: Interface Firm OASIS Comparison Summary for PJM > NYISO

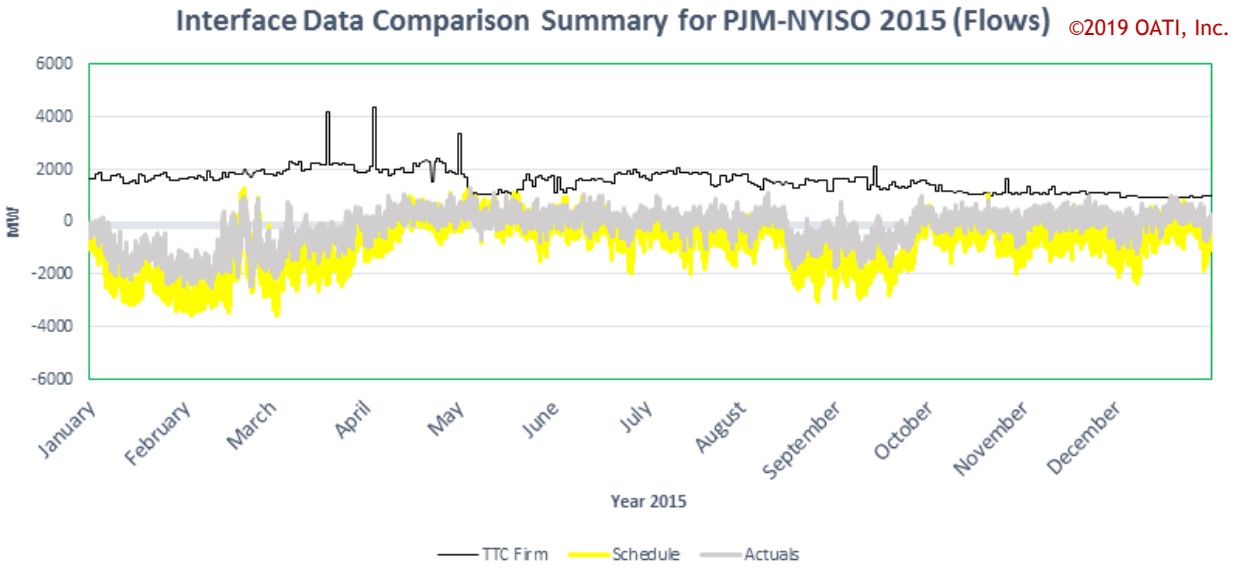


Figure 5.1-2k: Interface Flow Comparison Summary for PJM > NYISO

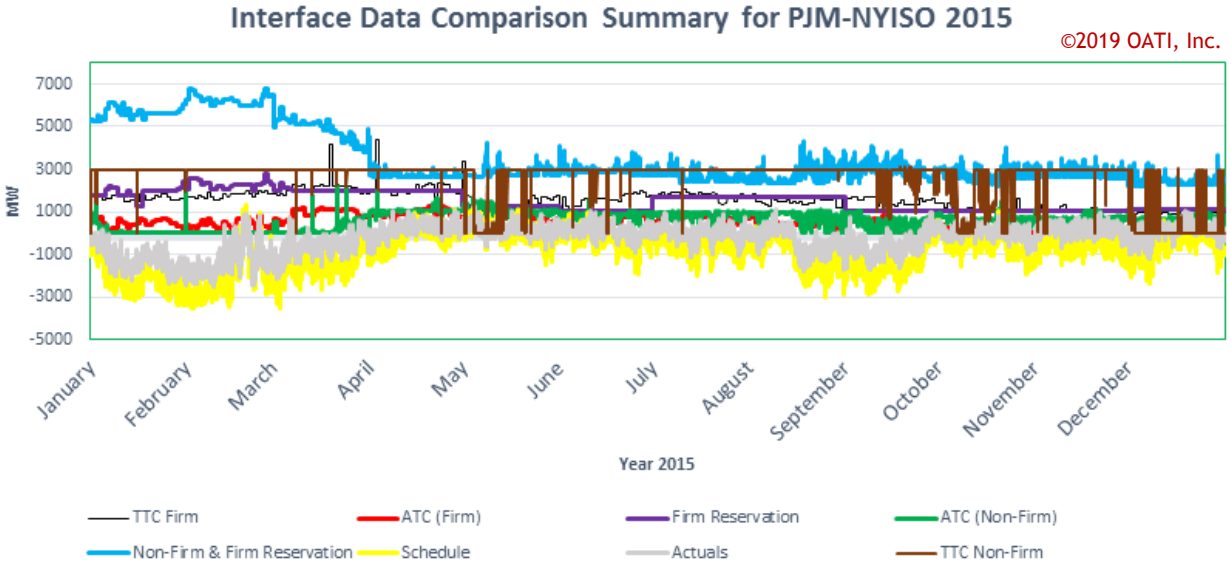


Figure 5.1-2l: Interface Comparison Summary for PJM > NYISO

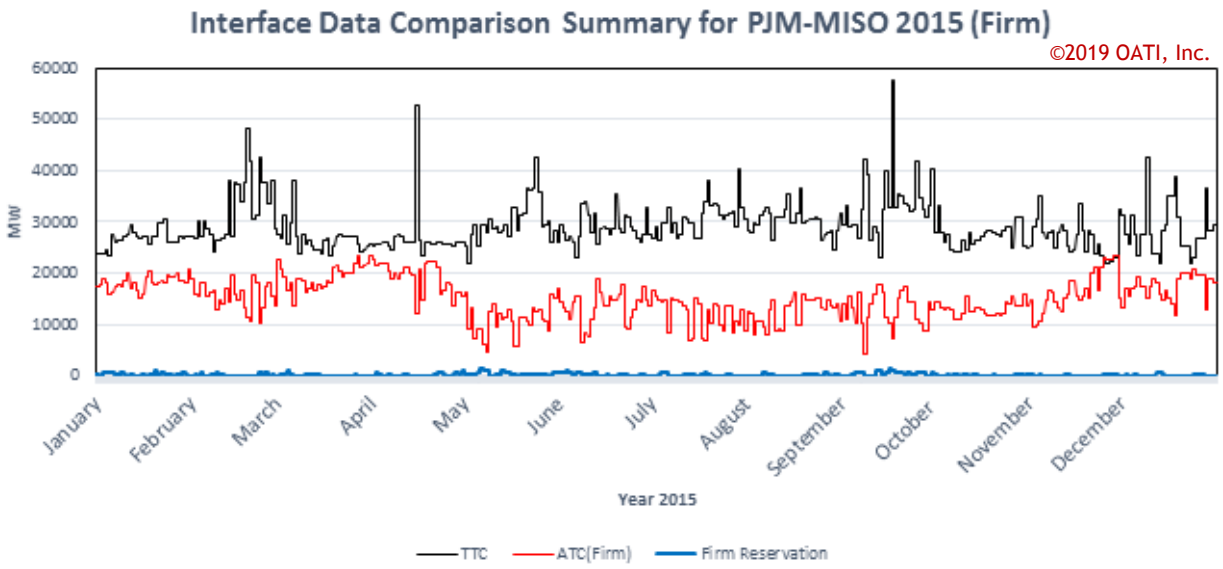


Figure 5.1-2m: Interface Firm OASIS Comparison Summary for PJM > MISO

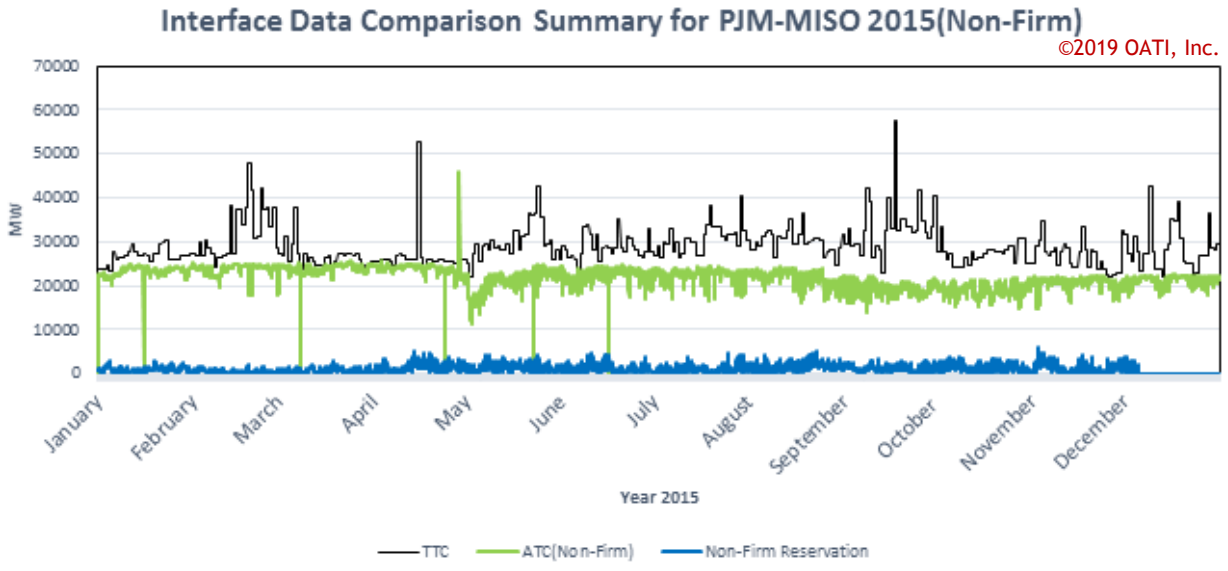


Figure 5.1-2n: Interface Non-Firm OASIS Comparison Summary for PJM > MISO

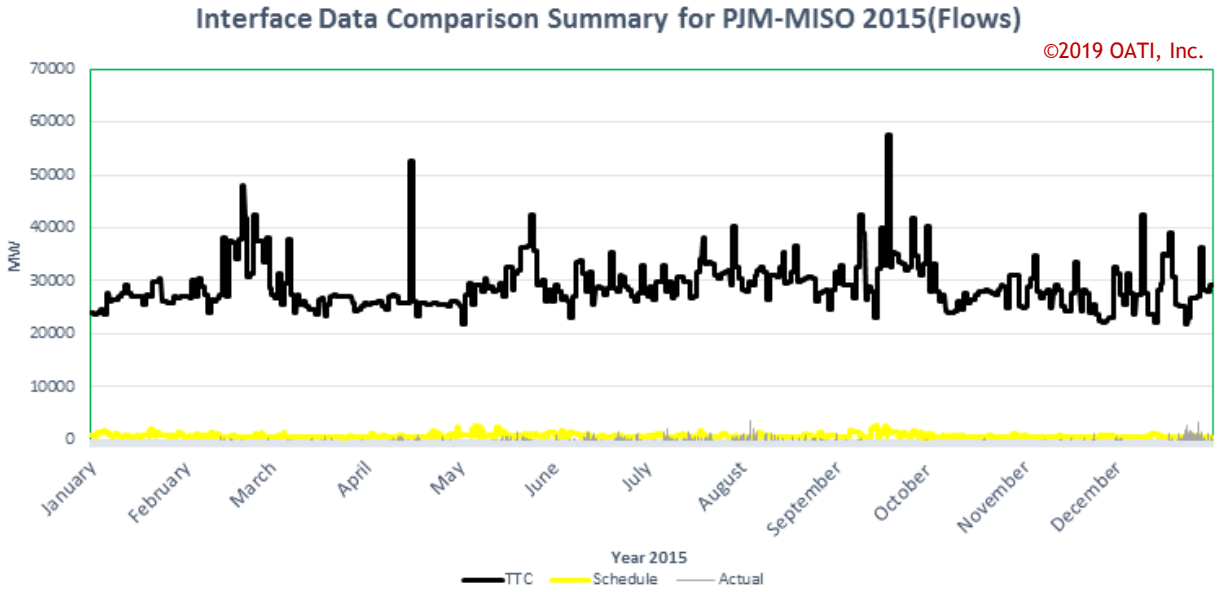


Figure 5.1-2o: Interface Flow Comparison Summary for PJM > MISO

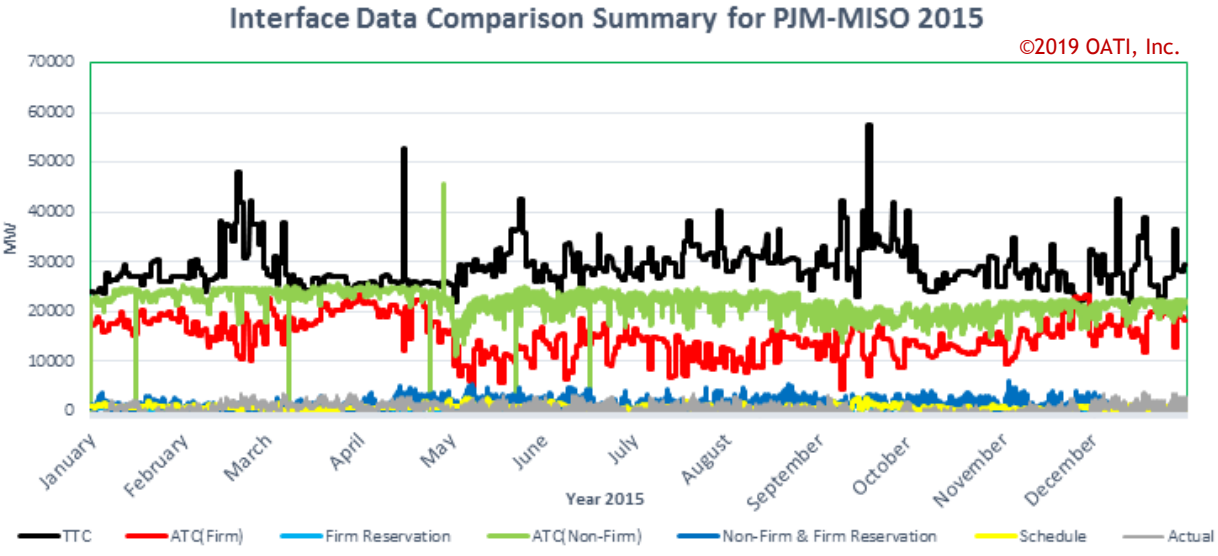


Figure 5.1-2p: Interface Comparison Summary for PJM > MISO

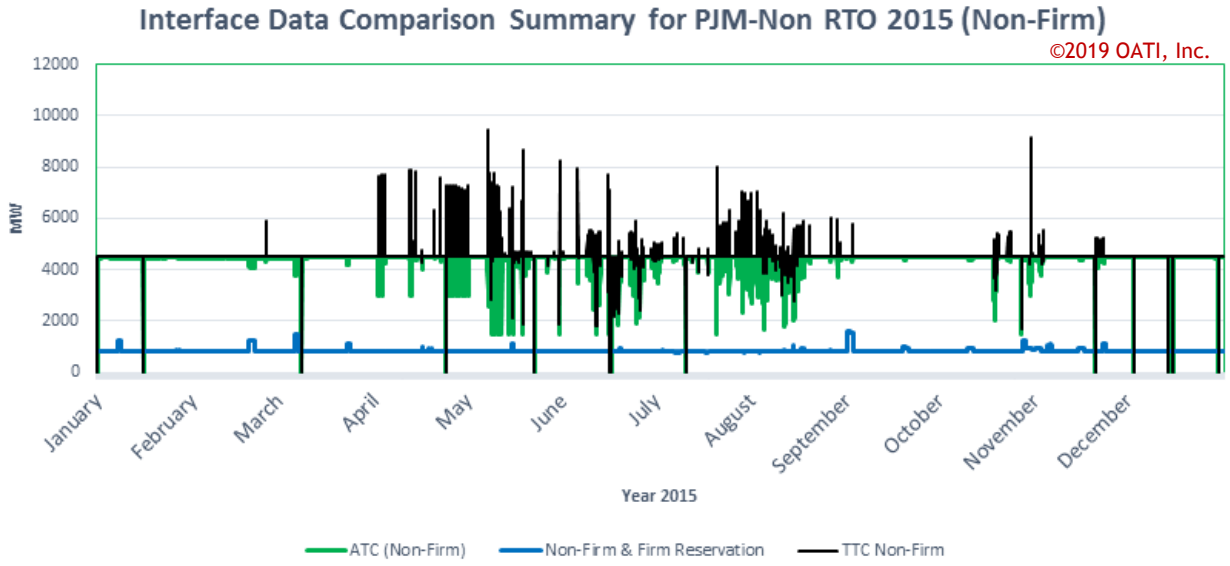


Figure 5.1-2q: Interface Non-Firm OASIS Comparison Summary for PJM > Non RTO Midwest

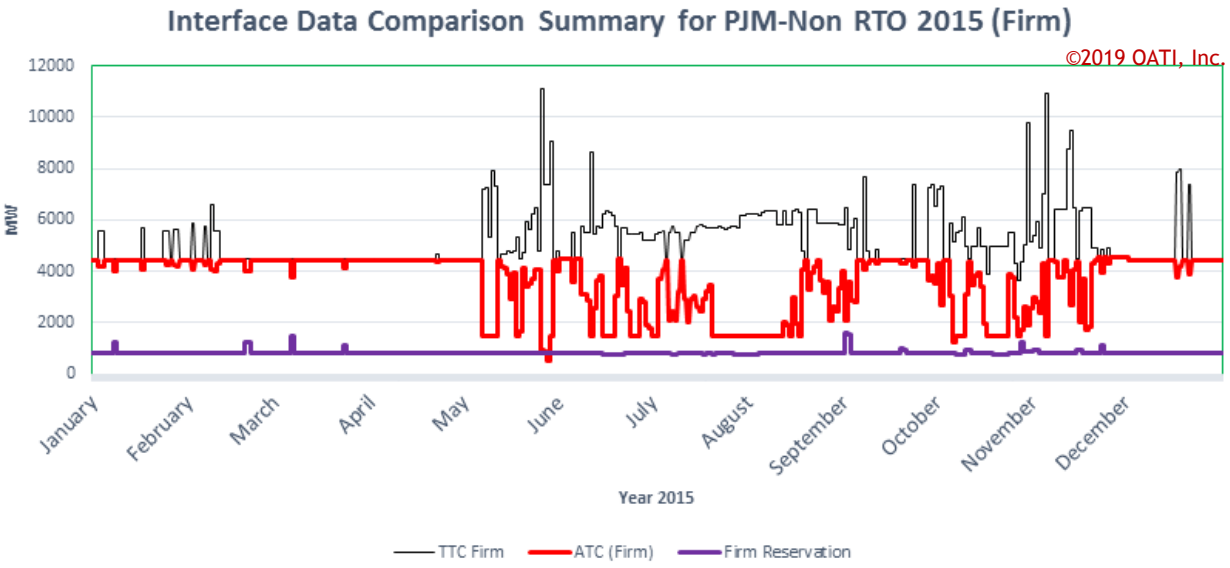


Figure 5.1-2r: Interface Firm OASIS Comparison Summary for PJM > Non RTO Midwest

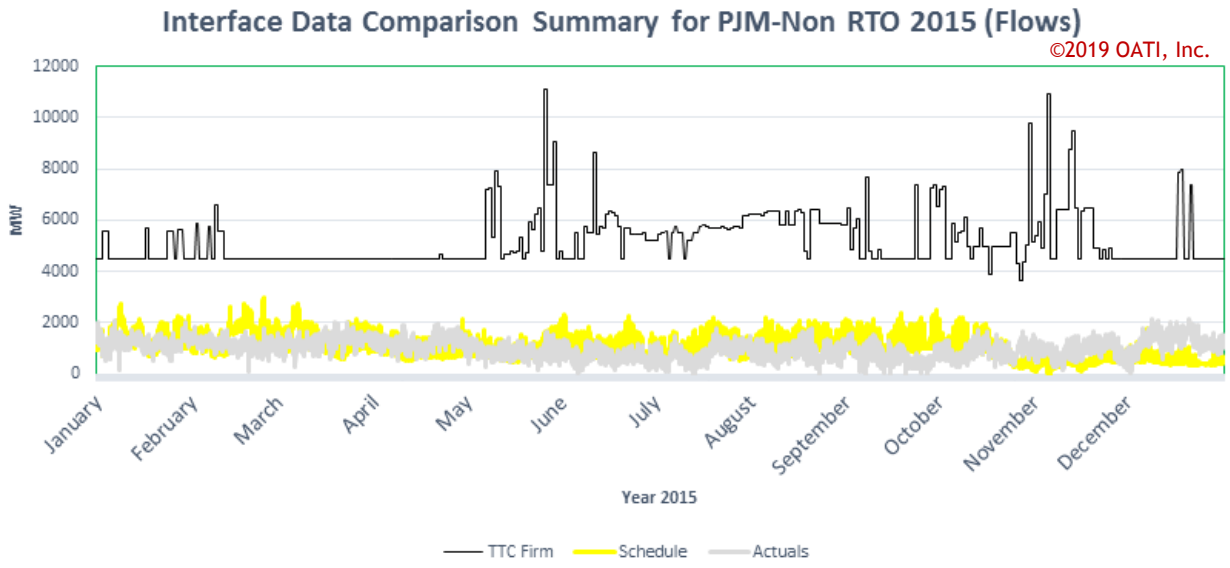


Figure 5.1-2s: Interface Flow Comparison Summary for PJM > Non RTO Midwest

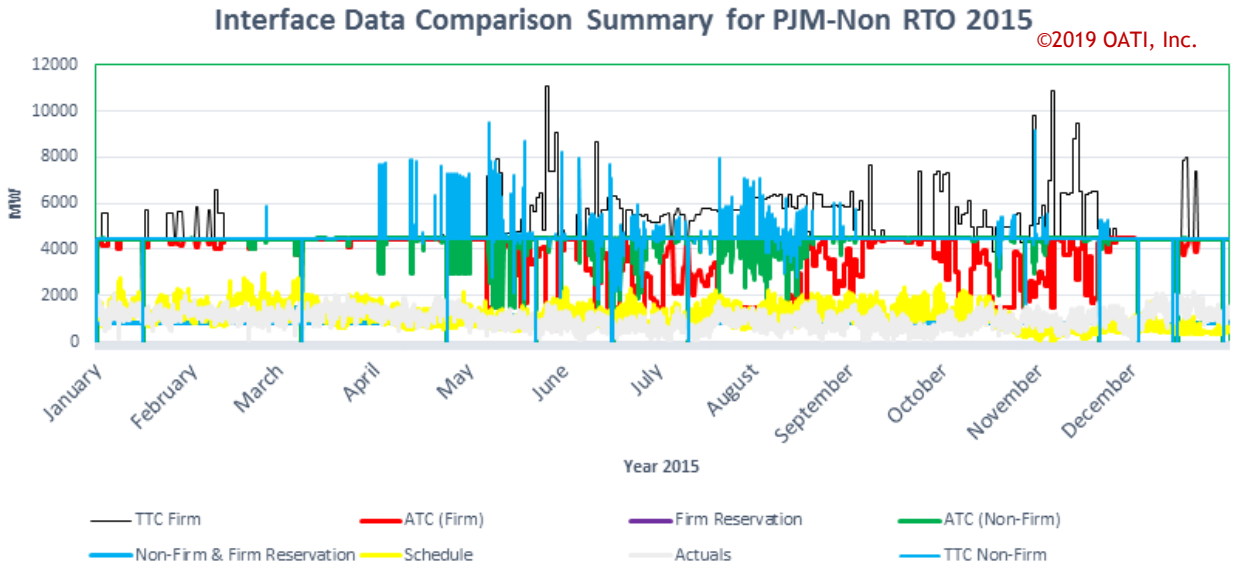


Figure 5.1-2t: Interface Comparison Summary for PJM > Non RTO Midwest

5.1.4 PJM Sub-Region Metrics Summary

Metrics for PJM sub-region and its interfaces between PJM and neighboring sub-regions are summarized in this section along with the study findings. Table 5.1-11a provides the interface summary related to PJM to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between PJM and other sub-regions. The top limiting flowgate for each interface is due to zero ATC and TLR, and is also summarized in Table 5.1-11b. Highlighted flowgates in Table 5.1-11b represent the most limiting flowgate that limits PJM interfaces due to ATC or TLR. Table 5.1-11c summarizes the reservation metrics for the sub-paths that define the PJM-MISO interface.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm[2]	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Count: Firm/ Non-Firm	TRU90 Count: Firm/ Non-Firm	Zero ATC Count: Firm/Non-Firm	U75 Schedule/ Actual Count	U90 Schedule/ Actual Count	Schedule Count above TTC	TLR Duration: Firm/Non-Firm (Hours)	TLR MWh: Firm/Non-Firm	TLR Count: Firm/Non-Firm
PJM > MISO	323/10748 (1621/8557)	26/10 (N/A)	7.45/0.09 (N/A)	0/167	0/10	0/0	0/0	0/0	0	0/0	0/0	0/0
MISO > PJM	293/5508 (14395/1277)	1708/3390 (178400/2440)	85.36/38 (92.53/65.64)	0/0	0/0	7480/2359	0/0	0/0	0	0/643	0/53016	0/1180
PJM > NYISO	49/5462 (21428/17024)	1/172 (N/A)	2/3.05 (N/A)	0/8	0/5	2136/2062	35/40	4/14	1	0/0	0/0	0/0
NYISO > PJM	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A	N/A	15/15	85/1010	29/638	0	0/160	0/75227	0/384
PJM > VACAR	1/136 (3301/1304)	0/0 (N/A)	0/0 (N/A)	0/0	0/0	576/54	0/0	0/0	0	0/245	0/29804	0/23
VACAR > PJM	218/3256 (858/1238)	10/52 (452/1491)	4.38/1.57 (34.48/10.74)	0/0	0/0	35/8	294/0	85/0	0	0/181	0/22476	0/350
PJM > TVA	29/317 (9454/196)	13/0 (N/A)	40/0 (N/A)	0/28	0/21	3384/290	0/0	0/0	0	0/0	0/0	0/0
TVA > PJM	210/1038 (3544/648)	1660/733 (145767/1320)	88.77/41.39 (97.6/67.07)	0/0	0/0	8687/228	869/0	60/0	0	0/162	0/12074	0/328
PJM > Non RTO Midwest	16/326 (7274/29)	9/4 (N/A)	36/1.21 (N/A)	0/0	0/0	0/24	0/0	0/0	0	0/0	0/0	0/0
Non RTO Midwest > PJM	6/2093 (1661/251)	0/109 (0/11)	0/4.95 (0/3.9)	0/0	0/0	828/221	0/0	0/0	0	0/268	0/9810	0/579

Table 5.1-11a: PJM Interface Summary

[2] The number in the brackets are referring to total reservation GWh value as calculated for the interface.

Top Limiting Flowgate	Firm Zero ATC		Non-Firm Zero ATC		Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count	Flowgate	Count	Flowgate	Count
PJM-MISO	**LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR**	**2496**	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	176	None	0	None	0
PJM-TVA	St Louis South Interface	465	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	131	None	0	None	0
PJM-Non RTO Midwest	None	0	Wheatland-Petersburg 345 l/o Rockport-Jefferson 765	75	None	0	None	0
PJM-VACAR	SHAWNEE 345/500 KV XFMR (FLO) DELL-SAN SOUCI 500 KV	2042	**Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345**	**298**	None	0	**310 - Person-Halifax 230 kV line l/o Wake-Heritage 500 kV**	**8**
PJM-NYISO	East Towanda-East Sayre 138 (flo) Watercure-Mainesburg 345	884	EAST TOWANDA-EAST SAYRE 115 (FLO) NORTH MESHOPPEN-LENOX 115	815	None	0	None	0

Table 5.1-11b: PJM Zero ATC and TLR Top Limiting Flowgates

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Firm Refused Based on Total Firm TSR	Non-Firm Confirmed TSR Count	Non-Firm Refused TSR Count	% Non-firm Refused based on Total Non-firm TSR
PJM-ALTE	37	0	0	2651	2	0.075
PJM-ALTW	30	0	0	55	0	0
PJM-AMIL	10	0	0	238	0	0
PJM-CIN	29	0	0	4526	8	0.176
PJM-IPL	0	0	0	3110	0	0
PJM-MEC	50	0	0	128	0	0
PJM-MECS	93	26	26.88	511	0	0
PJM-NIPS	0	0	0	15	0	0
PJM-WEC	75	0	0	249	0	0

Table 5.1-11c: PJM-MISO Paths Reservation Summary

Based on the above summary results, the following observations were noted.

1. The MISO-PJM interface is the most limiting interface in PJM based on refused TSR count, TLR duration, and TLR count. TVA-PJM is the most limiting interface based on Zero ATC count.
2. The PJM-NYISO interface is the most reserved interface based on the confirmed GWh.
3. The NYISO-PJM interface is the most loaded interface for RT operation in PJM based on U90 count (schedule). It should be noted that the schedules reported on this interface are significantly lower than actual flow. Schedules may not always represent the actual value because of the RT configuration of the system as well as generation to load schedules that may not be reported.
4. No firm TLRs were called on interfaces from or to PJM; however, non-firm TLRs were called on MISO-PJM, NYISO-PJM, PJM-VACAR, VACAR-PJM, Non RTO Midwest-PJM, and TVA-PJM. This points to overloads that were mitigated by either cutting non-firm schedules and/or market re-dispatch.
5. The top limiting flowgate in terms of firm transmission service is LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR. The top limiting flowgate in terms of non-firm transmission service is Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345.
6. The top limiting TLR flowgate is 310 – Person-Halifax 230 kV line l/o Wake-Heritage 500 kV, which occurred on the PJM-VACAR interface.

PJM sub-region metrics are summarized below. Table 5.1-11d provides the TLR summary for the PJM sub-region. Table 5.1-11e provides the most limiting flowgate that limits the PJM sub-region due to AFC or TLR. Table 5.1-11f provides the most limiting binding constraint that limits the PJM sub-region during the RT market. Table 5.1-11g provides the most limiting binding constraint that limits the PJM sub-region during the RT market due to market flow.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
PJM	0/254	0/59804	0/23

Table 5.1-11d: PJM TLR Sub-Region Summary

PJM	Firm Zero AFC		Non-Firm Zero AFC		Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count	Flowgate	Count	Flowgate	Count
Top limiting flowgate	LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR	2496	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345	176	None	0	310 – Person-Halifax 230 kV line l/o Wake-Heritage 500 kV	8

Table 5.1-11e: PJM Top Limiting Flowgate for Zero AFC and TLR

PJM	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour count	Binding Constraints Name	Congestion cost
Top Binded Constraint	Laporte-Michigan City 138 1 (MISO)	300	Dixon-McGirr Road 10714 138 (COMED)	$6.1 M

Table 5.1-11f: Most Limiting Binding Constraint in the PJM Sub-Region Due to RT Congestion Cost

PJM	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour Count	Binding Constraints Name	Congestion cost
Top Binded Constraint	Laporte-Michigan City 138 1 (MISO)	319	H471-Quad Cities 0404 345 (COMED)	$2.4 M

Table 5.1-11g: Most Limiting Binding Constraints in PJM to the Market Flow Impacts

1. In the PJM sub-region, the top limiting flowgate for firm service is LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR. The top limiting flowgate for the non-firm service is Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345. The Kyger Creek-SPORNAEP flowgate shows up in AFC twice as well as showing up in zero ATC.
2. No firm TLRs were called on interfaces in the PJM sub-region; however, non-firm TLRs were called, and the 310 – Person-Halifax 230 kV line l/o Wake-Heritage 500 kV flowgate had the most TLRs being called upon.
3. In the PJM market, the most binding constraint due to congestion cost is Dixon-McGirr Road 10714 138, and the most binding constraint due to market flow is H471-Quad Cities 0404 345.
4. A separate comparison was performed which is included in Appendix D based on the DOE's *Annual U.S. Transmission Data Review* that publishes a list of the top 25 constraints observed in the PJM sub-region. The most limiting binding constraints, such as Burnham-Munster, Byron-Cherry Valley, and Laporte-Michigan city, listed in this study also show up in the DOE's *Annual U.S. Transmission Data Review*.

5.2 MISO

5.2.1 Sub-Region Metrics

5.2.1.1 Market Flow Metric based on Binding Count and Market Flow Settlement Cost

This study developed market flow metrics for MISO and identified the five most limiting flowgates based on the market binding constraint counts. To calculate the market flow cost associated with these constraints, MTM settlement costs (MTM-credit/payment) were used. The absolute value of the MTM cost was used if the MTM cost was negative. For each hour, binding constraints with same monitored elements were grouped and congestion costs summed. For MISO market metric calculation, only binding constraints owned by that market were included.

All unique constraints (based on monitored element) for the year were listed out and their corresponding yearly counts were calculated.

Each constraint was assigned a total yearly congestion cost.

The top five constraints for both count and congestion cost will be listed.

The results from the market flow metrics for the MISO sub-region are provided in Table 5.2-2a and Table 5.2-2b.

Sub-region metrics based on RT congestion cost were not developed as MISO does not post RT congestion cost.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours
1	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	1085	20.75%
2	BUNSONVILL_EUGNE_SULLIVAN_CASEY	631	12.06%
3	Eau_Claire_Arpin_345kV_flo_Stone_Lake_Gardner_Park_345kV	410	07.84%
4	Rising_345_138_xfmr_flo_Clinton_Brokaw_345kV	337	06.44%
5	Mercr_IP_Galesburg_161kV_flo_Nelson_Electric_Jct_345	199	03.81%

Table 5.2-2a: Five Most Limiting MISO Binding Constraints to the Market Flow Impacts (by Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)	% Congestion Cost
1	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	6.3	14.28%
2	Rising_345_138_xfmr_flo_Clinton_Brokaw_345kV	5.8	13.13%
3	Batesvill_Hubbl_138kV_flo_Tanners_Creek_Miami_Fort_345kV	4.2	09.48%
4	Mercr_IP_Galesburg_161kV_flo_Nelson_Electric_Jct_345	2.1	04.66%
5	Munster_345_Trf_flo_WiltCen_Dumont	2.0	04.53%

Table 5.2-2b: Five Most Limiting MISO Binding Constraints to the Market Flow Impacts (by Cost)

5.2.1.2 Sub-region TLR Metrics

This study also developed TLR metrics for the MISO sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

Sub-region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
MISO	0	0	0	871	67348	1639

Table 5.2-3a: TLR metrics for the MISO sub-region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
MISO	None	0	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	539	21171
				Volunteer – Phipps Bend 500 FLO Conasauga – Mosteller 500	241	8757
				Volunteer – Phipps Bend 500 kV FLO Jefferson – Rockport 765 kV	275	7475
				Person-Halifax 230 kV line l/o Wake-Carson 500 kV	128	11868
				Trimble Cty – Clifty Creek 345kV line for the loss of Jefferson – Rockport 765 kV line	79	3638

Table 5.2-3b: Top Five Limiting Flowgates (Count-Based) for the MISO Sub-region

5.2.2 Interface Metrics

5.2.2.1 Transmission Service Request Metric

These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces. With regards to the interface with PJM, although PJM posts data on the basis of sub-paths, MISO posts data only for sub-region to sub-region, not sub-paths. The study also calculated firm and non-firm reservation MW confirmed and refused on the interfaces. The results from the TSR metric for the MISO interfaces are provided in Tables 5.2-4a through 5.2-4d.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
MISO > PJM	278	1708	86.00%
PJM > MISO	323	26	7.45%
MISO > SPP	33	9	21.43%
SPP > MISO	23	51	68.91%
MISO > TVA	17	193	91.90%
TVA > MISO	6	30	83.33%
MISO > SOCO	9	102	91.89%
SOCO > MISO	942	53	5.33%
MISO > NON RTO MIDWEST	120	0	0.00%
NON RTO MIDWEST > MISO	22	2	8.3%
MISO > WAUE	8	0	0.00%
WAUE > MISO	*	*	*

Table 5.2-4a: Firm Confirmed and Refused TSR count

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
MISO > PJM	5508	3390	37.5%
PJM > MISO	10748	10	0.09%
MISO > SPP	984	444	31.09%
SPP > MISO	0	34	100%
MISO > TVA	149	155	50.99%
TVA > MISO	29	22	13.13%
MISO > SOCO	275	130	32.10%
SOCO > MISO	254	21	7.64%
MISO > NON RTO MIDWEST	83	82	49.70%

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
NON RTO MIDWEST > MISO	1645	56	3.3%
MISO > WAUE	122	79	39.30%
WAUE > MISO	*	*	*

*WAUE being in WECC, data related to it was not calculated.

Table 5.2-4b: Non-Firm Confirmed and Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
MISO > PJM	14395010	178400498	92.53
PJM > MISO	1621200	N/A	N/A
MISO > SPP	19880914	252288	1.25
SPP > MISO	752688	1074266	58.50
MISO > TVA	5454096	2641704	32.63
TVA > MISO	5428530	1870815	25.63
MISO > SOCO	2826898	1264424	30.91
SOCO > MISO	3396428	228864	6.31
MISO > NON RTO MIDWEST	447790	0	100.00
NON RTO MIDWEST > MISO	365279	1152	3.14
MISO > WAUE	13232250	0	0.00
WAUE > MISO	*	*	*

Table 5.2-4c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
MISO > PJM	1277642	2440871	65.64
PJM > MISO	8557095	N/A	N/A
MISO > SPP	254747	59007	18.81
SPP > MISO	0	295085	100
MISO > TVA	39182	424820	91.56
TVA > MISO	3766	45603	92.37
MISO > SOCO	48531	1264424	96.30
SOCO > MISO	22057	2725	11.00
MISO > NON RTO MIDWEST	45776	100578	68.72

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
NON RTO MIDWEST > MISO	162634	4552	2.72
MISO > WAUE	15358	7802	33.69
WAUE > MISO	*	*	*

Table 5.2-4d: Non-Firm Confirmed and Refused Reservation MWh

5.2.2.2 Transmission Reservation Utilization Metric

The results from the Transmission Service Utilization metric for the MISO interfaces are provided in Tables 5.2-5a and 5.2-5b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
MISO > PJM	0	0
PJM > MISO	0	167
MISO > SPP	0	0
SPP > MISO	0	0
MISO > TVA	0	0
TVA > MISO	0	0
MISO > SOCO	0	0
SOCO > MISO	683	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > MISO	0	0
MISO > WAUE	0	0
WAUE > MISO	*	*

Table 5.2-5a: TRU75 for Firm and Non-Firm Reservations

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
MISO > PJM	0	0
PJM > MISO	0	10
MISO > SPP	0	0
SPP > MISO	0	0
MISO > TVA	0	0
TVA > MISO	0	0

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
MISO > SOCO	0	0
SOCO > MISO	347	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > MISO	0	0
MISO > WAUE	0	0
WAUE > MISO	*	*

Table 5.2-5b: TRU90 for Firm and Non-Firm Reservations

5.2.2.3 Zero ATC Metrics

The results from the ATC Metric for MISO interfaces are provided in Table 5.2-6.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
MISO > PJM	7480	2359
PJM > MISO	0	0
MISO > SPP	8563	3061
SPP > MISO	8733	3242
MISO > TVA	8493	4511
TVA > MISO	8520	6
MISO > SOCO	8440	1506
SOCO > MISO	233	207
MISO > NON RTO MIDWEST	7363	299
NON RTO MIDWEST > MISO	604	1182
MISO > WAUE	5829	1003
WAUE > MISO	*	*

Table 5.2-6: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.2-1a through 5.2-1d).

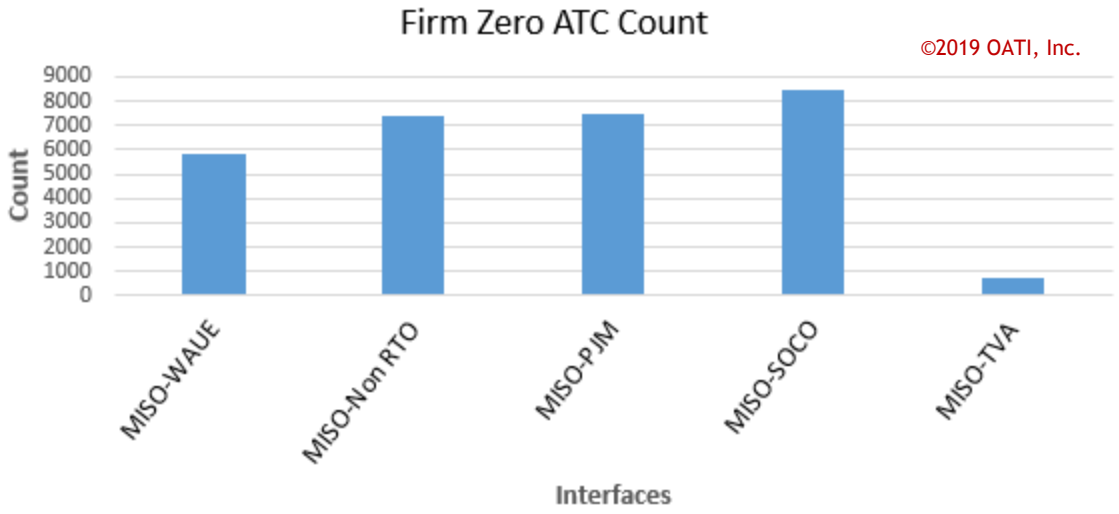


Figure 5.2-1a: Firm Zero ATC Count

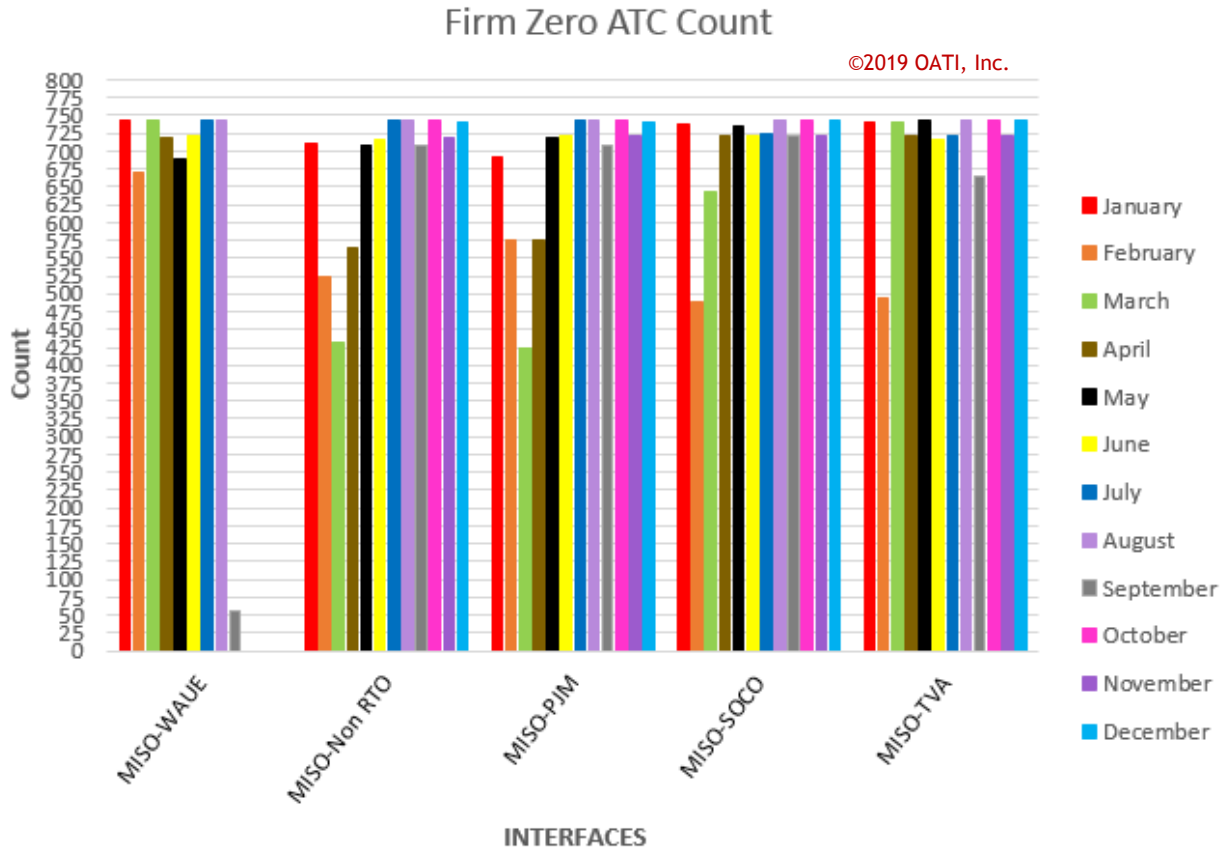


Figure 5.2-1b: Firm Zero ATC Count

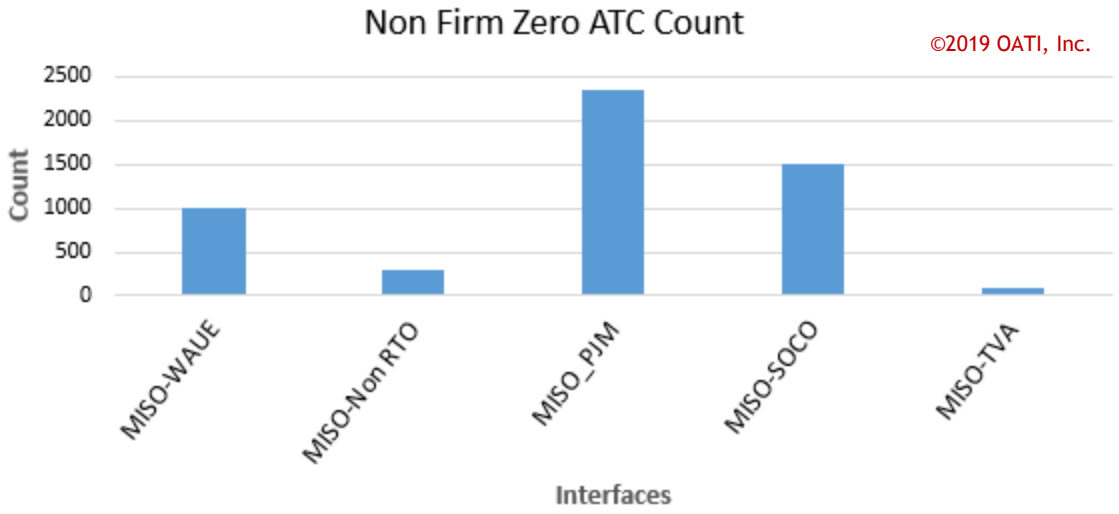


Figure 5.2-1c: Non-Firm Zero ATC Count

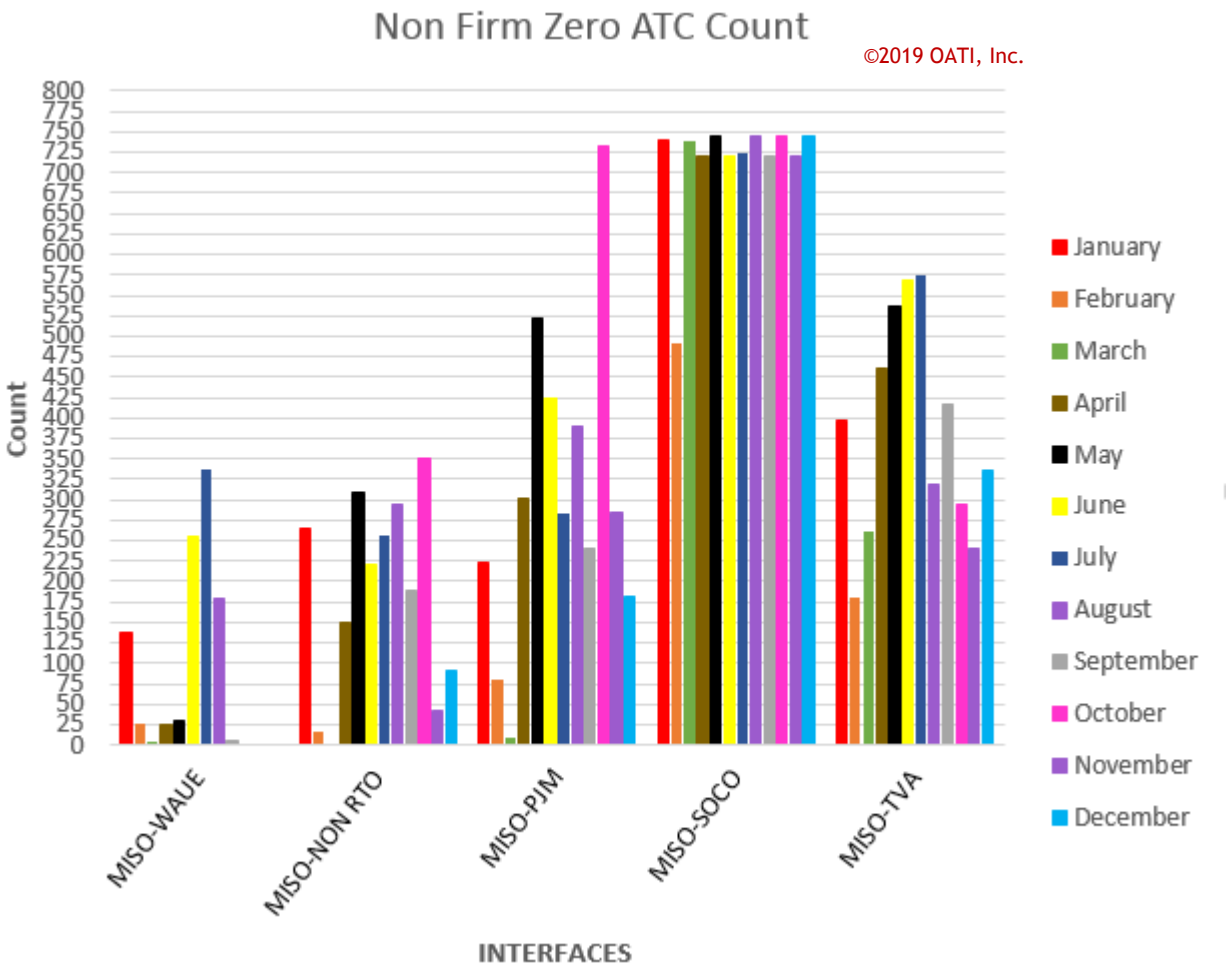


Figure 5.2-1d: Non-Firm Zero ATC Count

From the above ATC graphs, it can be observed that the MISO-PJM and MISO-SOCO interfaces have a higher zero ATC for both firm and non-firm than the other interfaces. The latter part of the year has a higher count for the firm ATC, and for non-firm, the initial part has a higher count. Monthly graphs tend to follow the same pattern for both firm and non-firm ATC for these interfaces.

5.2.2.4 Schedule Utilization Metrics and Actual flow Metrics

The results from the schedule utilization metrics and actual flow metrics for the MISO interfaces are provided in Table 5.2-8a and Table 5.2-8b.

Actual flows metrics were calculated as further explained. As mentioned before, MISO posts directional actual flow data for each of its interfaces. They post these data as Received and Delivered flow values. MISO actual flow utilization is based on directional data.

Interface	U75 Schedule Count	U90 Schedule Count
MISO > PJM	0	0
PJM > MISO	0	0
MISO > SPP	0	0
SPP > MISO	0	0
MISO > TVA	0	0
TVA > MISO	97	21
MISO > SOCO	0	0
SOCO > MISO	608	287
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > MISO	0	0
MISO > WAUE	0	0
WAUE > MISO	*	*

Table 5.2-8a: Schedule Flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
MISO > PJM	7	3
PJM > MISO	0	0

Interface	U75 Actual Count	U90 Actual Count
MISO > SPP	0	0
SPP > MISO	0	0
MISO > TVA	5	1
TVA > MISO	174	49
MISO > SOCO	0	0
SOCO > MISO	26	4
MISO > NON RTO MIDWEST	1	1
NON RTO MIDWEST > MISO	0	0
MISO > WAUE	0	0
WAUE > MISO	*	*

Table 5.2-8b: Actual Flow Utilization Metric

Metrics for interfaces based on schedule count above the TTC were also developed. The results for the metrics are provided in Table 5.2-8c.

Interface	Schedule Count above TTC
MISO > PJM	0
PJM > MISO	0
MISO > SPP	0
SPP > MISO	0
MISO > TVA	0
TVA > MISO	0
MISO > SOCO	0
SOCO > MISO	0
MISO > NON RTO MIDWEST	0
NON RTO MIDWEST > MISO	0
MISO > WAUE	0
WAUE > MISO	*

Table 5.2-8c: Schedule Count above TTC

5.2.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metric for the interfaces are provided in Table 5.2-9a and Table 5.2-9b.

Interface	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
MISO > PJM	0	0	0	643	53015	1180
PJM > MISO	0	0	0	0	0	0
MISO > SPP	0	0	0	0	0	0
SPP > MISO	0	0	0	86	1839	178
MISO > TVA	0	0	0	41	3523	79
TVA > MISO	0	0	0	30	127	59
MISO > SOCO	0	0	0	55	2522	110
SOCO > MISO	0	0	0	4	190	8
MISO > NON RTO MIDWEST	0	0	0	25	815	51
NON RTO MIDWEST > MISO	0	0	0	35	979	76
MISO > WAUE	0	0	0	90	6103	186
WAUE > MISO	*	*	*	*	*	*

Table 5.2-9a: TLR Metrics for MISO Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
MISO > PJM	None	0	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	369	16704
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	240	8736
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	238	7226
				Person-Halifax 230 kV line l/o Wake-Carson 500 kV	128	11868
				Trimble Cty - Clifty Creek 345kV line for the loss of Jefferson - Rockport 765 kV line	79	3638
MISO > SPP	None	0	0	None	0	0
MISO > TVA	None	0	0	Widows Creek 500/161 bank flo Browns Ferry-Maury 500kv	61	1970
				Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	14	503
				Widows Creek - Sequoyah 500kV Line	2	942
				Widows Creek to Sequoyah 500kV	2	108
MISO > SOCO	None	0	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	108	2463

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
				Monroe-Bayshore345kVfloAllenJct-Monroe-Milan345kV	2	59
MISO > NON RTO MIDWEST	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	34	82
				Livingston-Crittenden 161 kV (flo) Livingston-North Princeton 161 kV	4	49
				Paradise Northeast Corridor	3	30
				Paradise_BRTAP_161_flo_Gibson_ABBrown_345	3	10
				Paradise-Big River Tap FLO Wilson1	3	23
MISO > WAUE	None	0	0	TEMP05 Mandan - Dickenson 230 kV (flo) Antelope Valley - Charlie Creek 345 kV	72	1190
				TMP131 Lacygne - W. Gardner 345 kV (FLO) Lacygne - Stillwell 345 kV	58	2078
				Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	40	2044
				Raun345_161kV_TR2_flo_Raun_SiouxCity_345	8	440
				Fort Smith 500/161 XF ftlo Lydia - Valliant 345 kV	3	67

Table 5.2-9b: Top Five TLR Limiting Flowgates (Count-Based) for MISO Interfaces

5.2.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual/scheduled flow for the whole year for all MISO interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

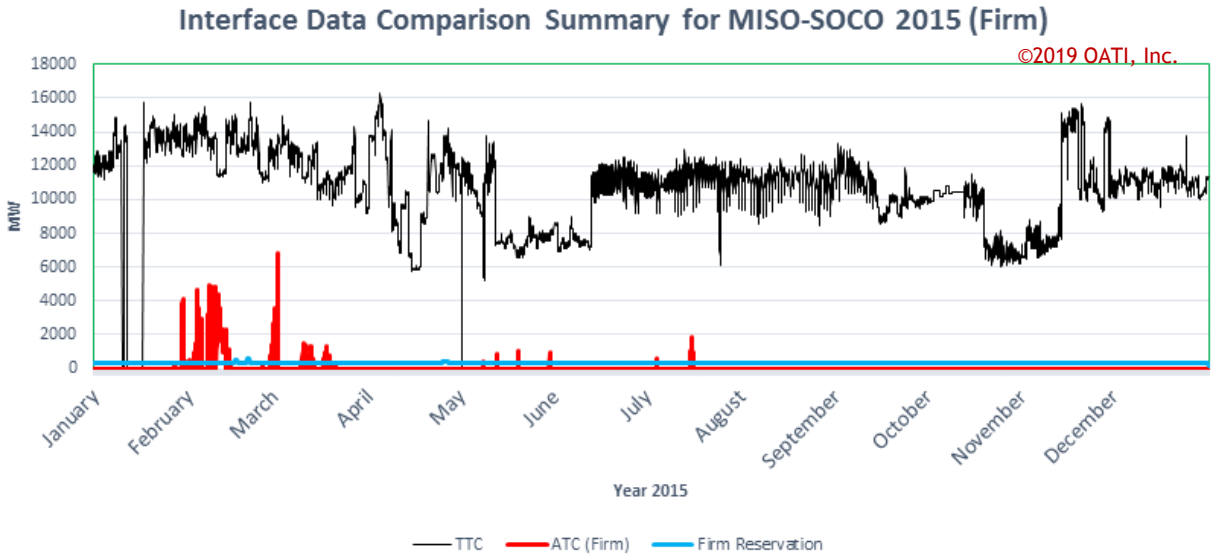


Figure 5.2-2a: Interface Firm OASIS Comparison Summary for MISO > SOCO

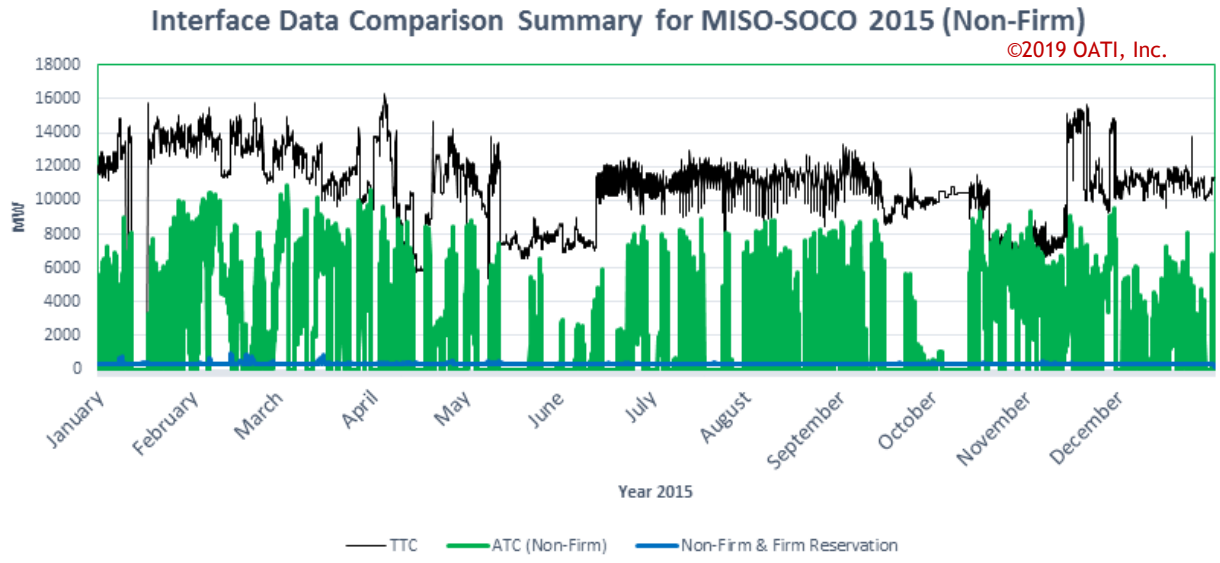


Figure 5.2-2b: Interface Non-firm OASIS Comparison Summary for MISO > SOCO

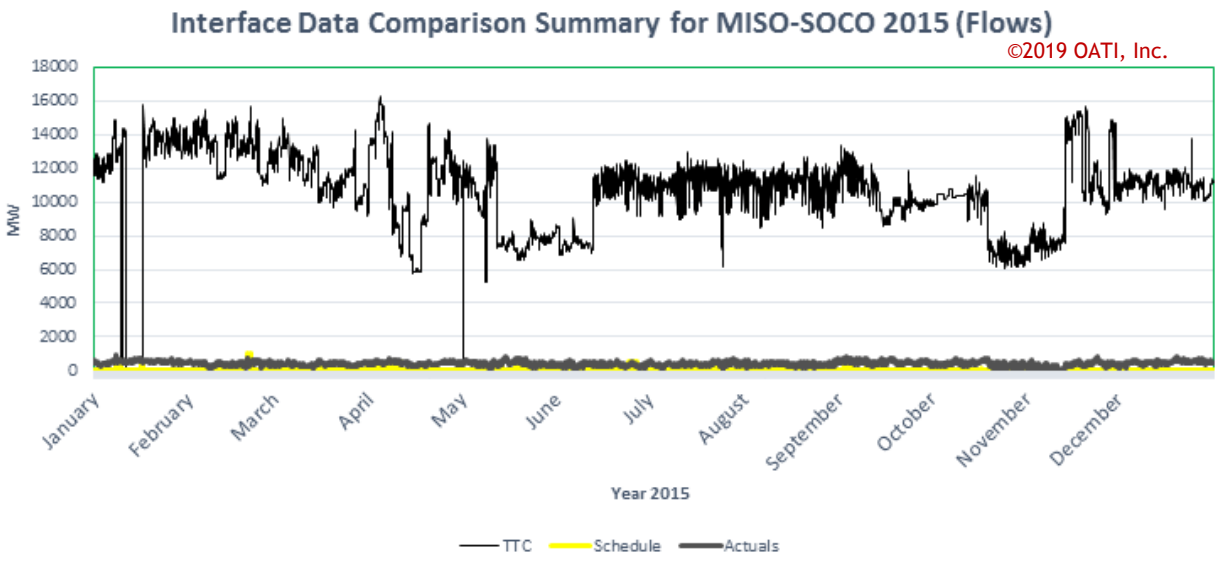


Figure 5.2-2c: Interface Flow Comparison Summary for MISO > SOCO

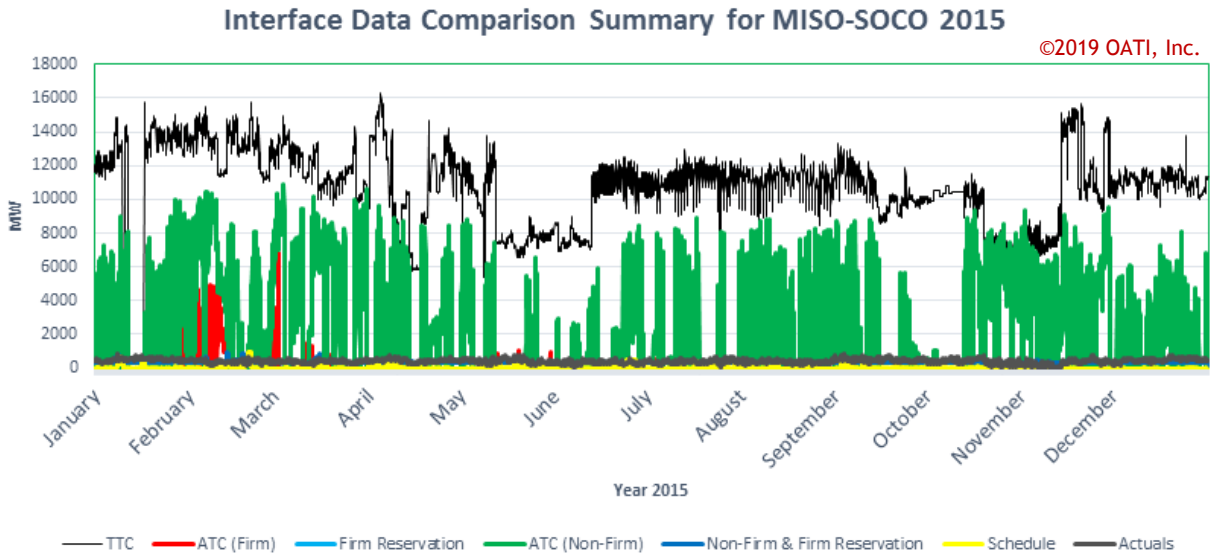


Figure 5.2-2d: Interface Comparison Summary for MISO > SOCO

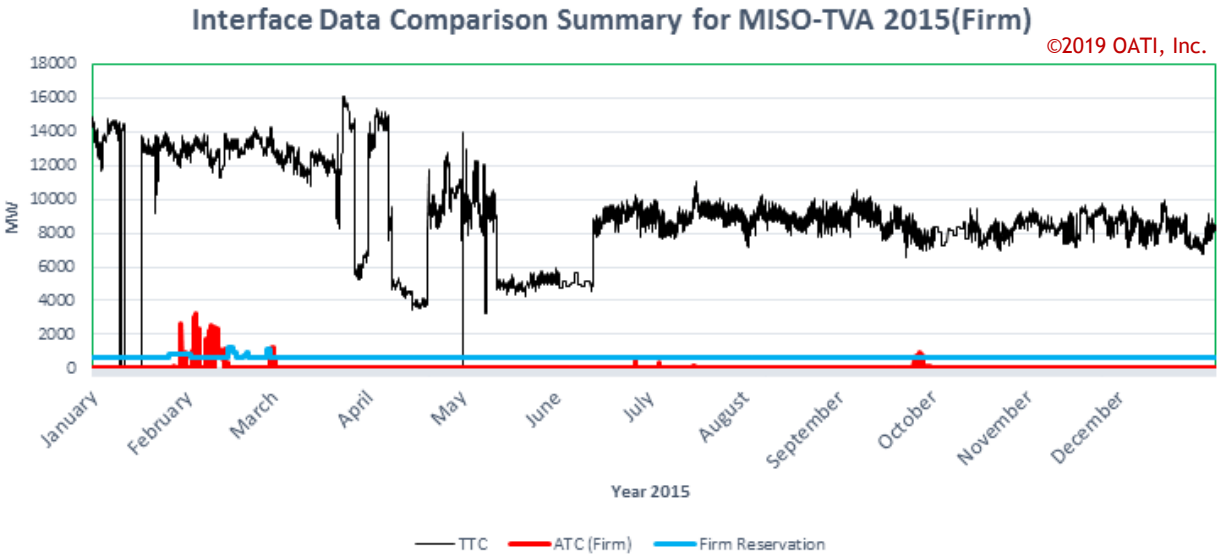


Figure 5.2-2e: Interface Firm OASIS Comparison Summary for MISO > TVA

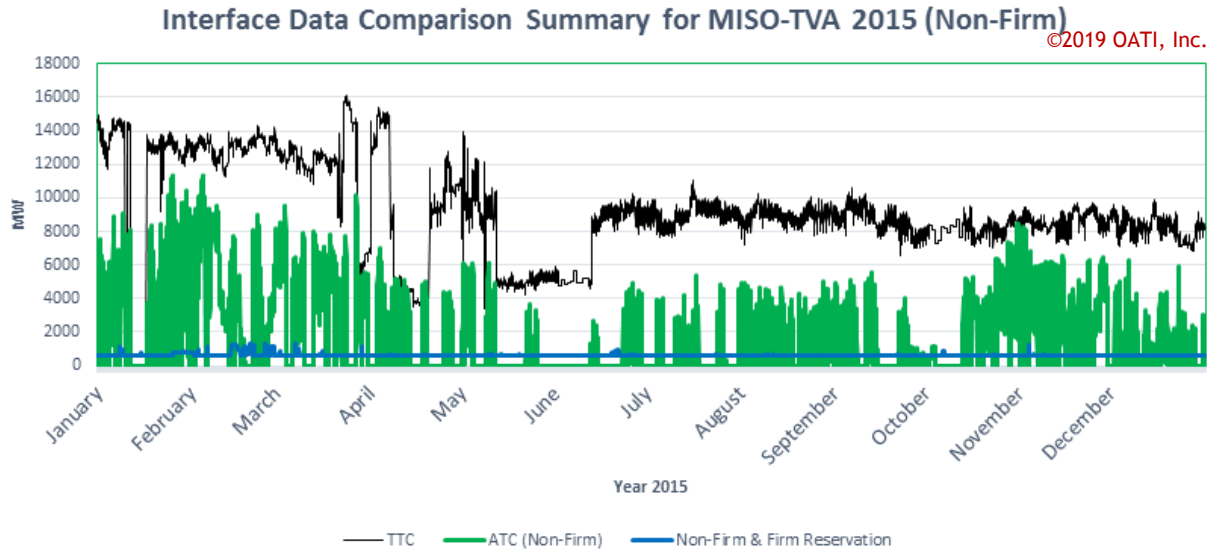


Figure 5.2-2f: Interface Non-Firm OASIS Comparison Summary for MISO > TVA

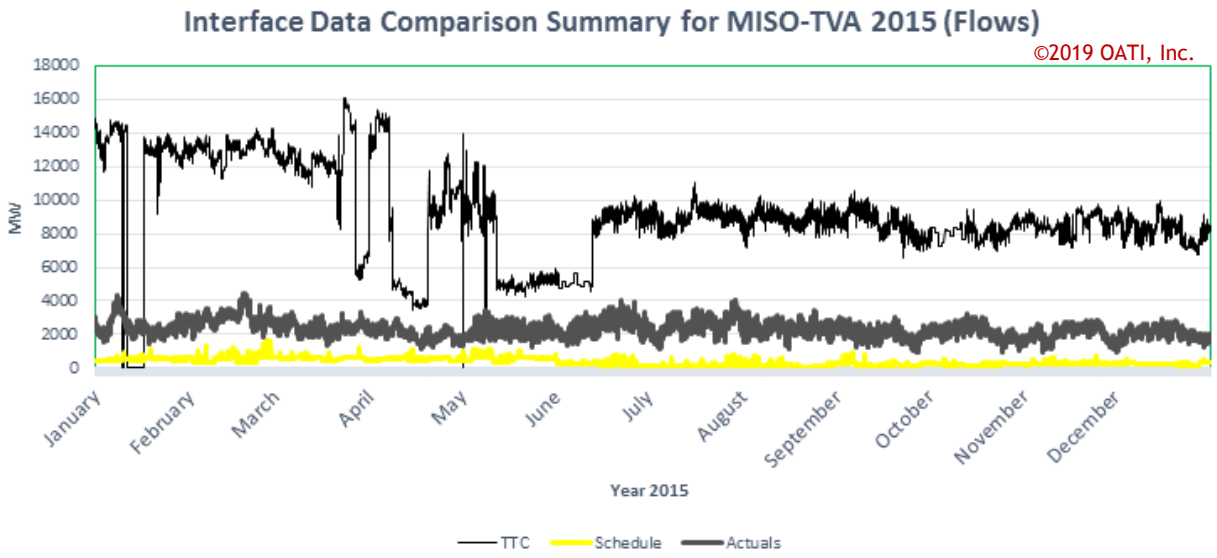


Figure 5.2.2g: Interface Flow Comparison Summary for MISO > TVA

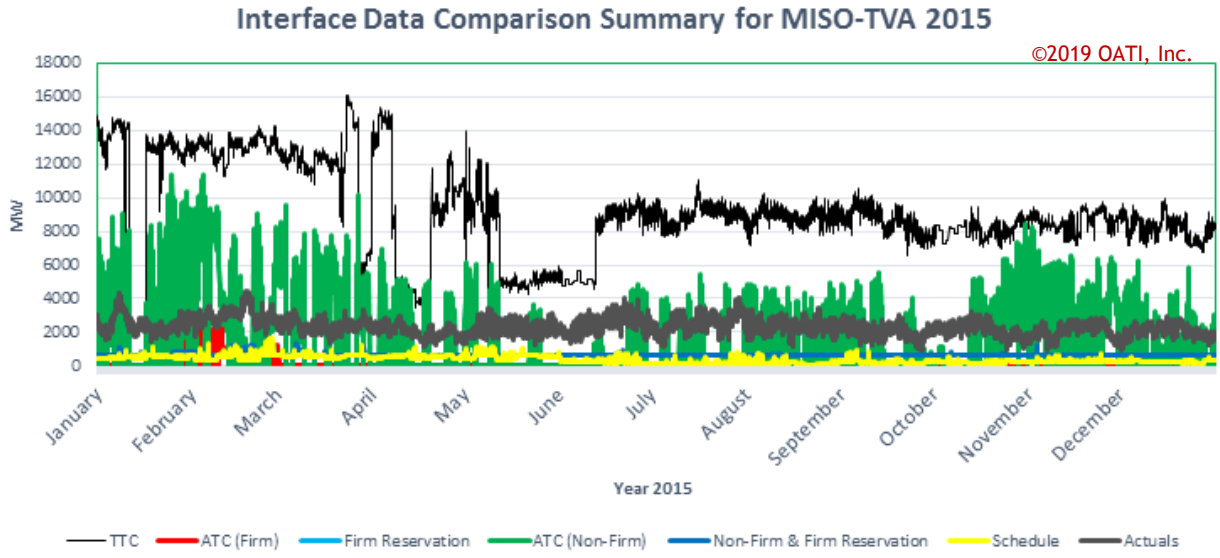


Figure 5.2-2h: Interface Comparison Summary for MISO > TVA

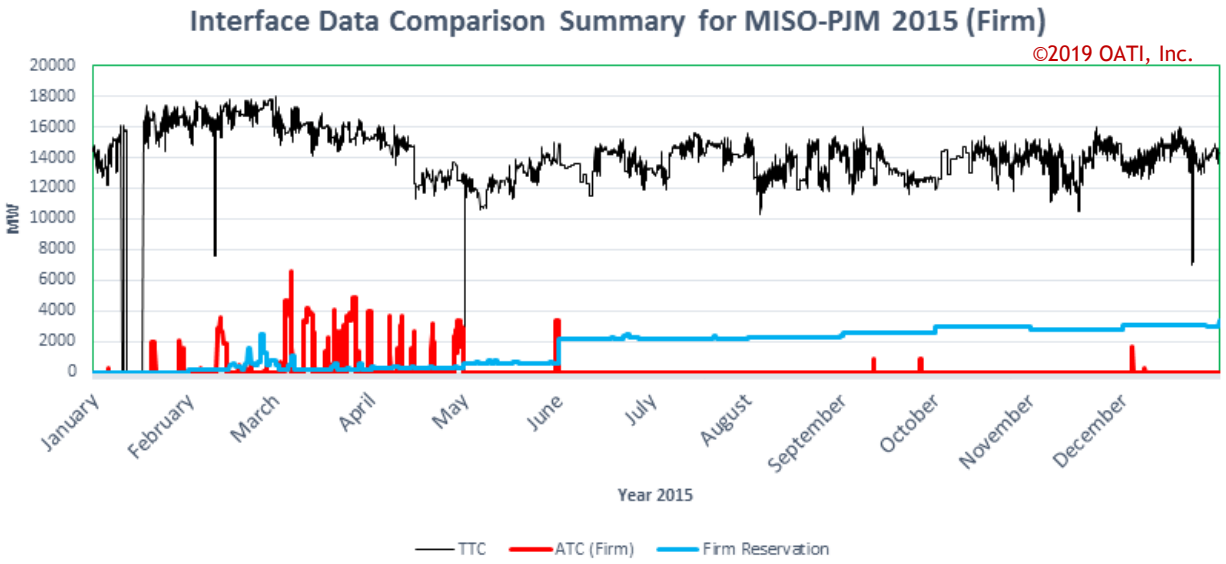


Figure 5.2-2i: Interface Firm OASIS Comparison Summary for MISO > PJM

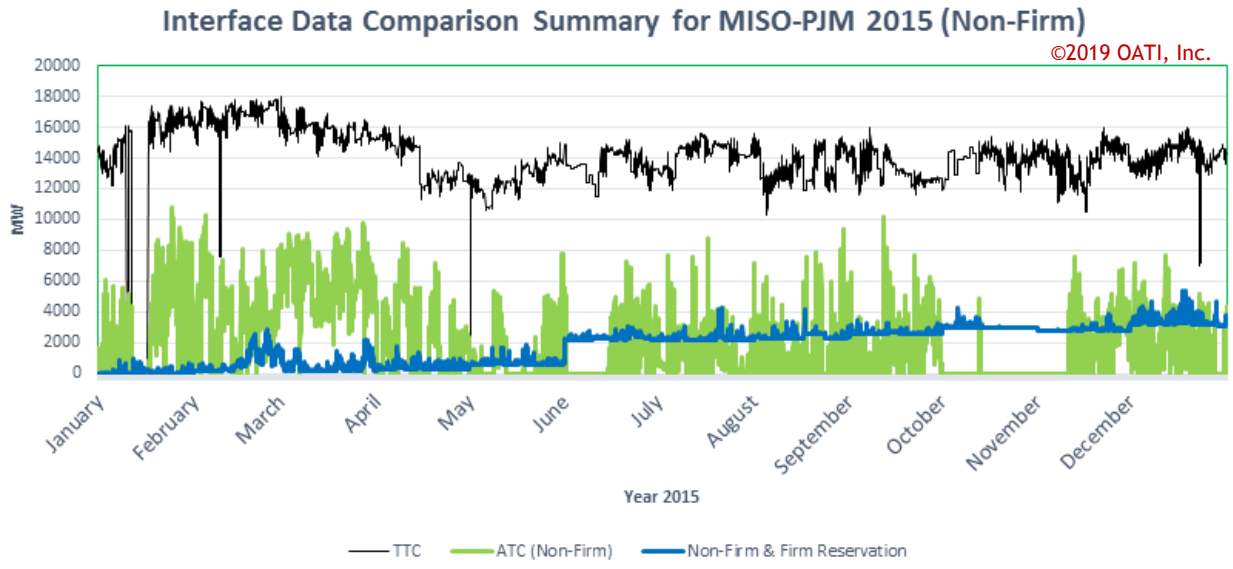


Figure 5.2-2j: Interface Non-Firm OASIS Comparison Summary for MISO > PJM

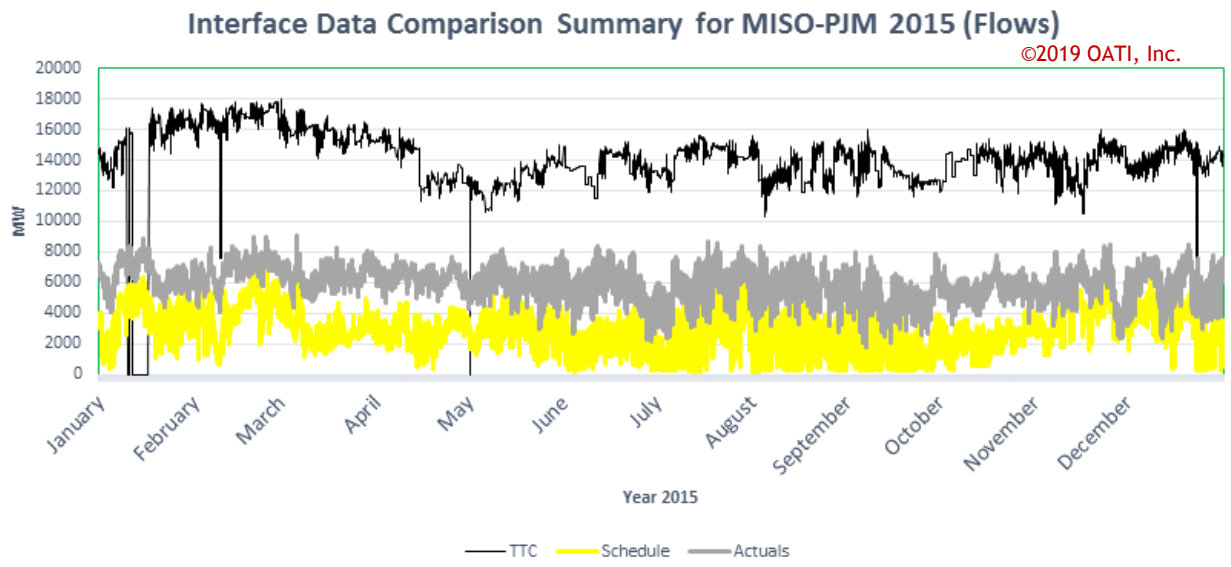


Figure 5.2-2k: Interface Flow Comparison Summary for MISO > PJM

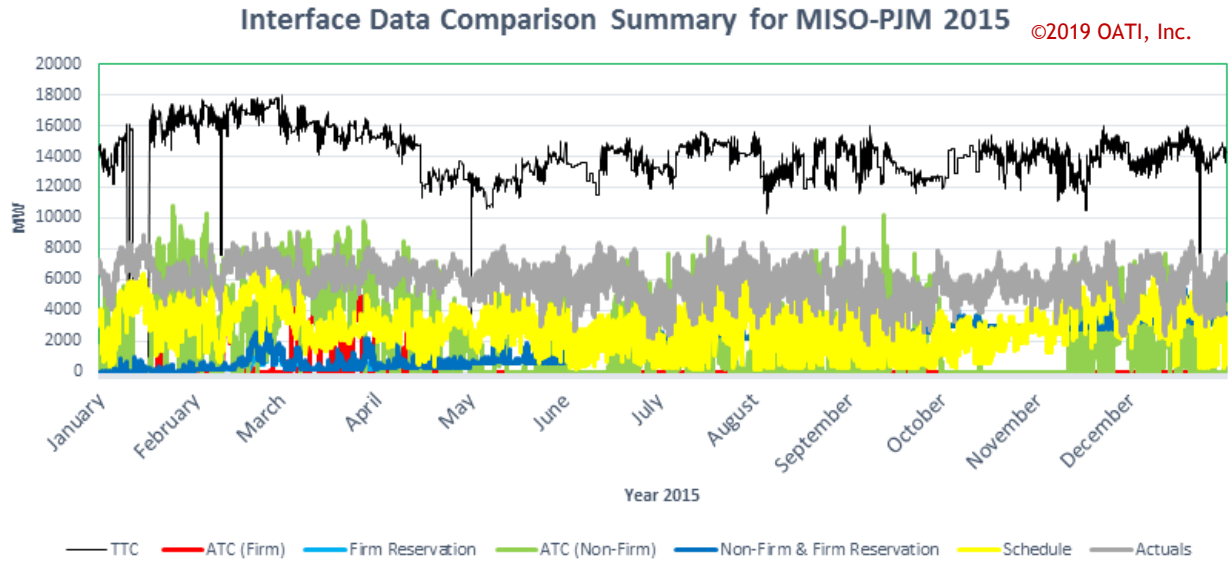


Figure 5.2-2l: Interface Comparison Summary for MISO > PJM

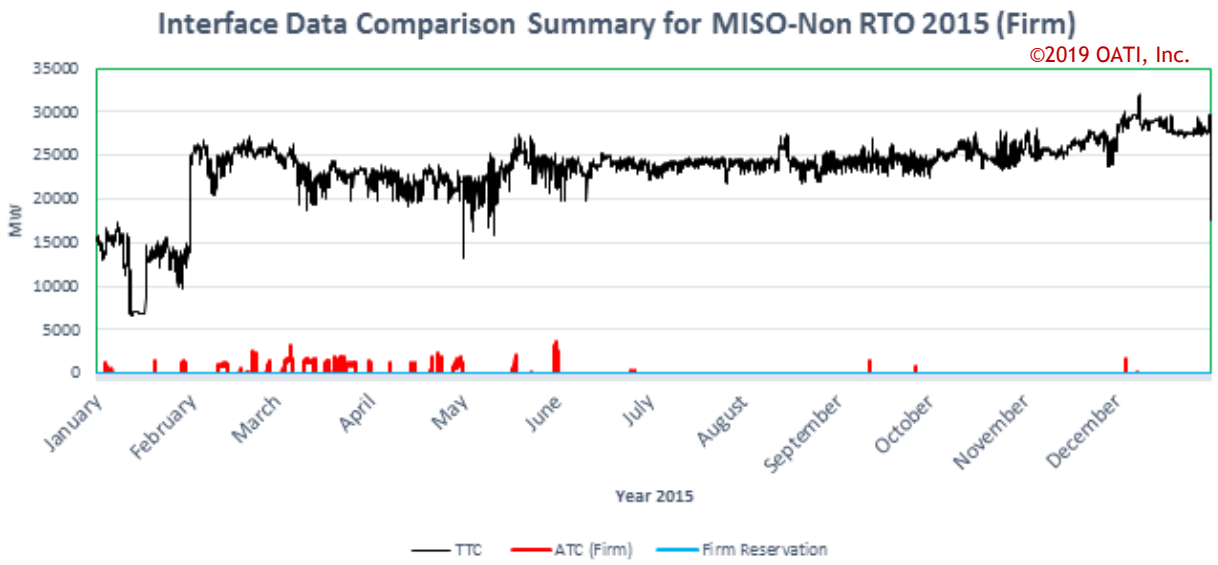


Figure 5.2-2m: Interface Firm OASIS Comparison Summary for MISO > Non RTO Midwest

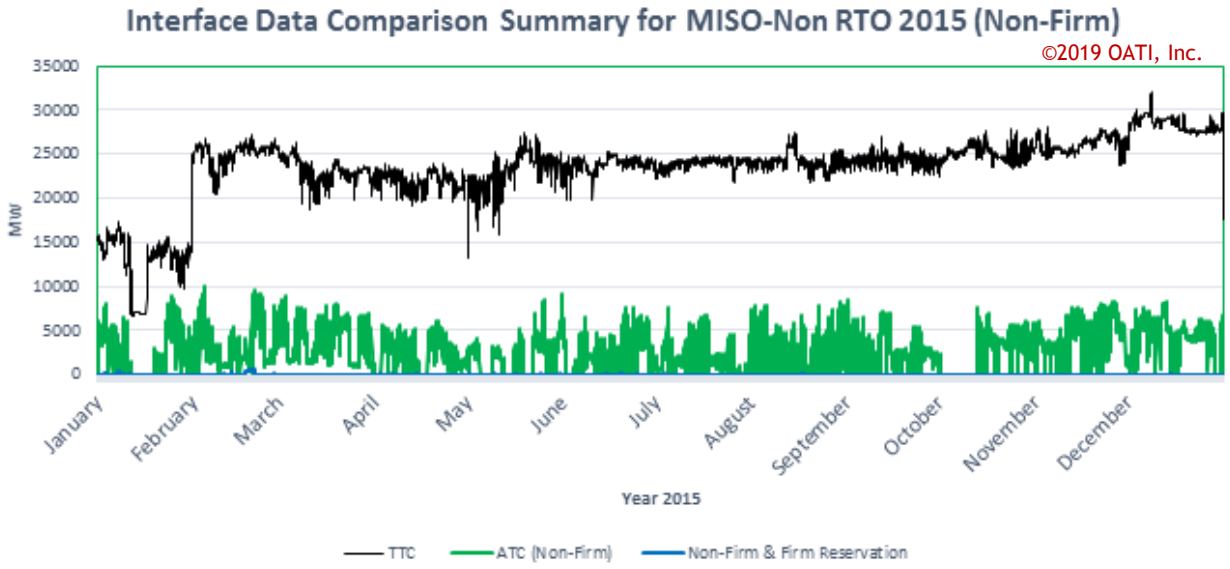


Figure 5.2-2n: Interface Non-Firm OASIS Comparison Summary for MISO > Non RTO Midwest

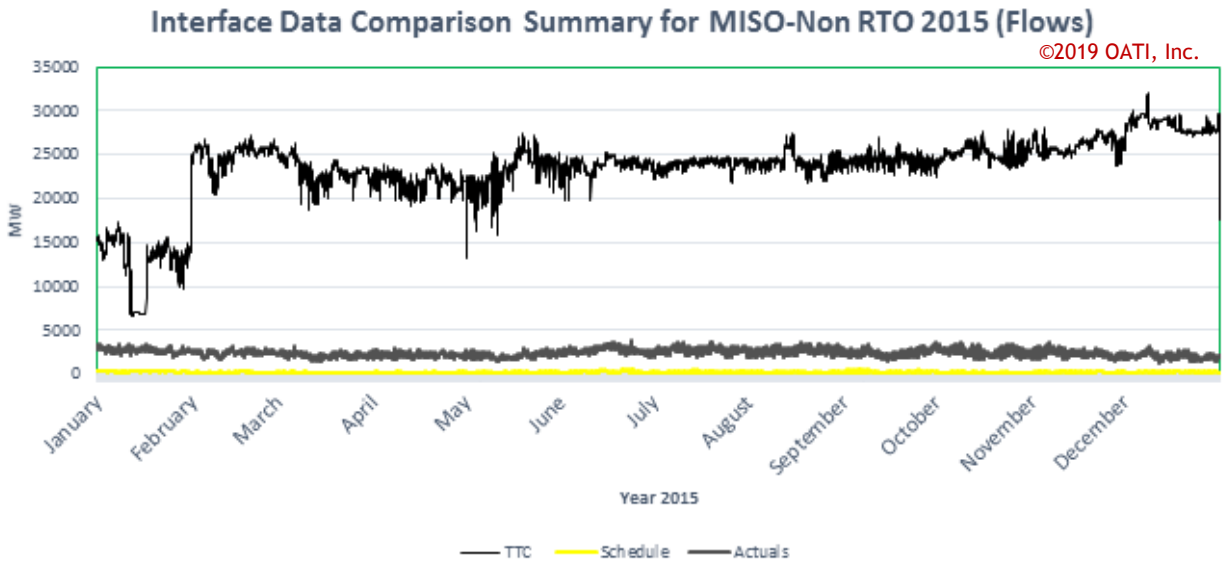


Figure 5.2-2o: Interface Flow Comparison Summary for MISO > Non RTO Midwest

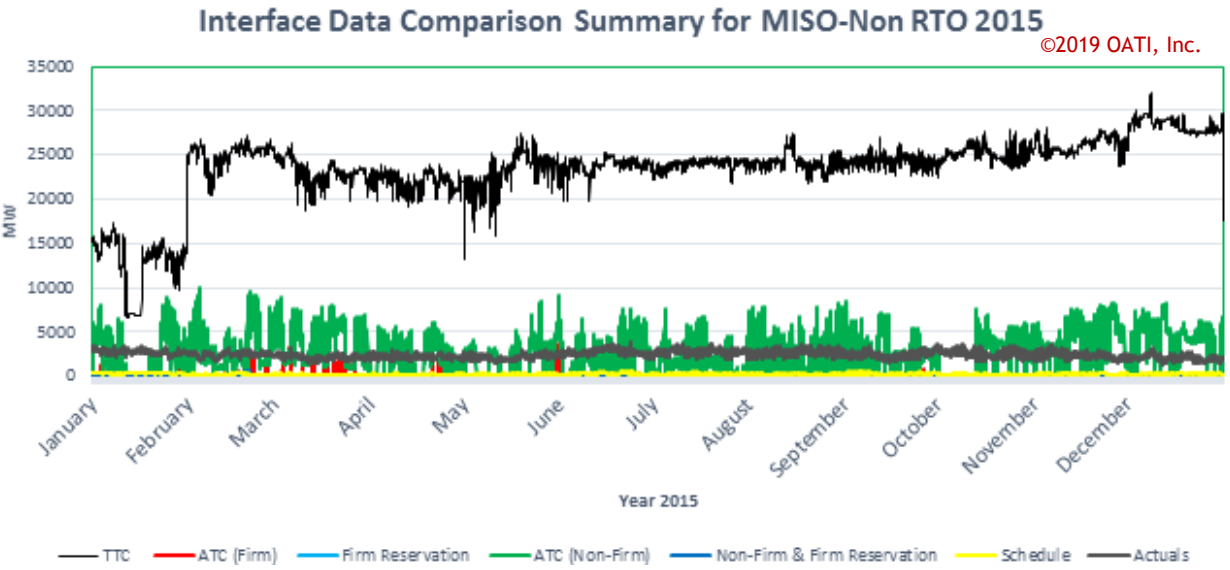


Figure 5.2-2p: Interface Comparison Summary for MISO > Non RTO Midwest

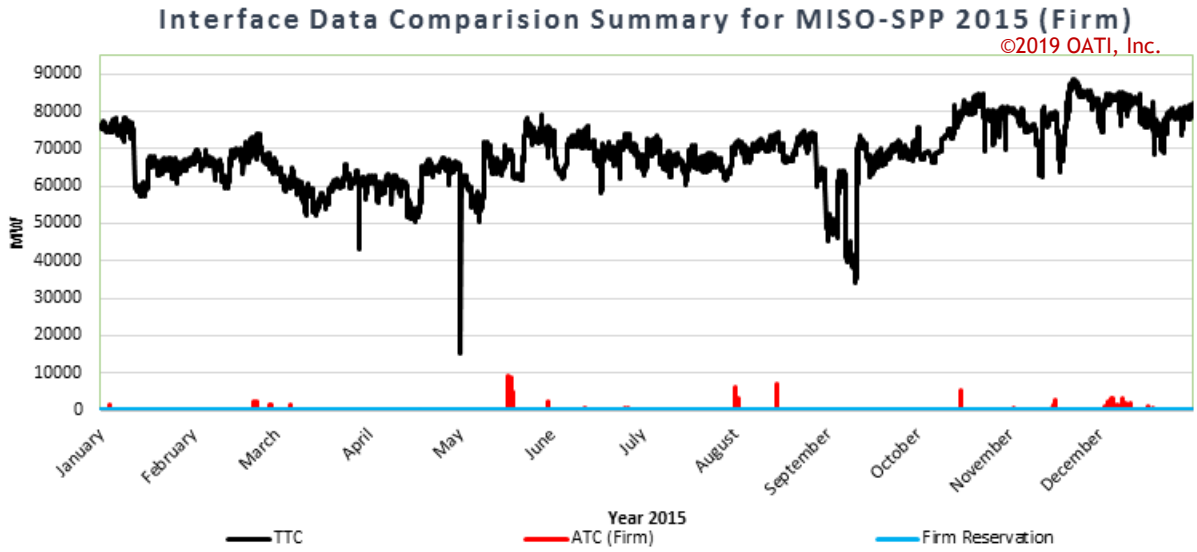


Figure 5.2-2q: Interface Firm OASIS Comparison Summary for MISO > SPP

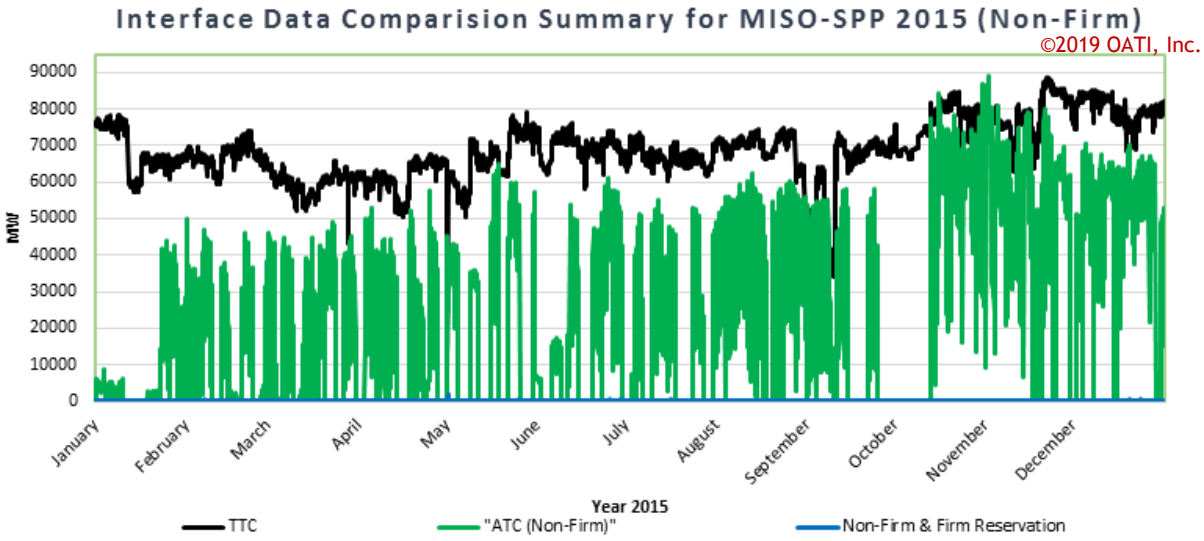


Figure 5.2-2r: Interface Non-Firm OASIS Comparison Summary for MISO > SPP

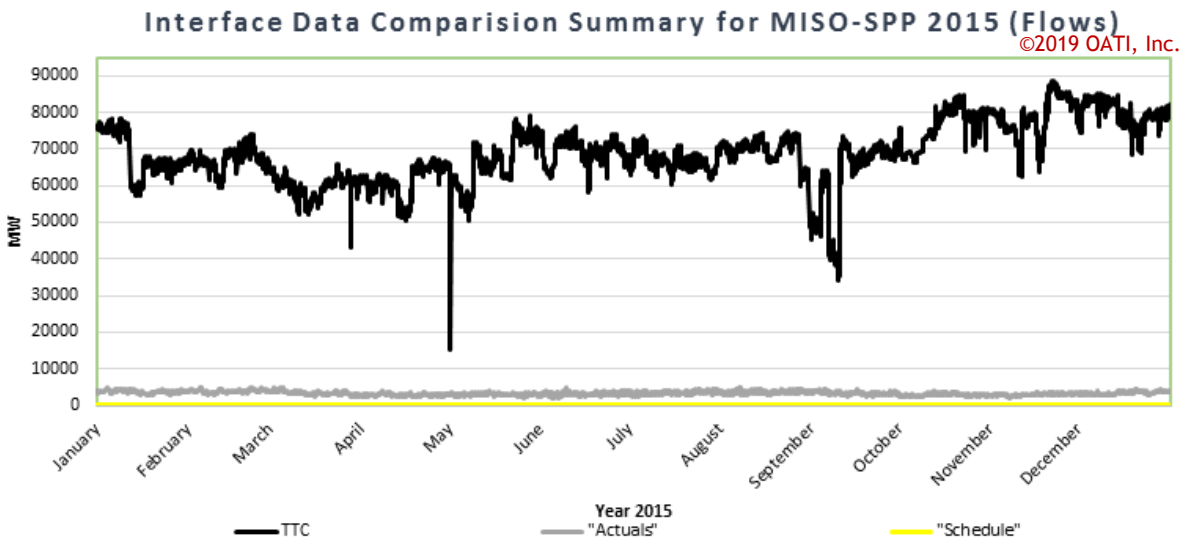


Figure 5.2-2s: Interface Flow Comparison Summary for MISO > SPP

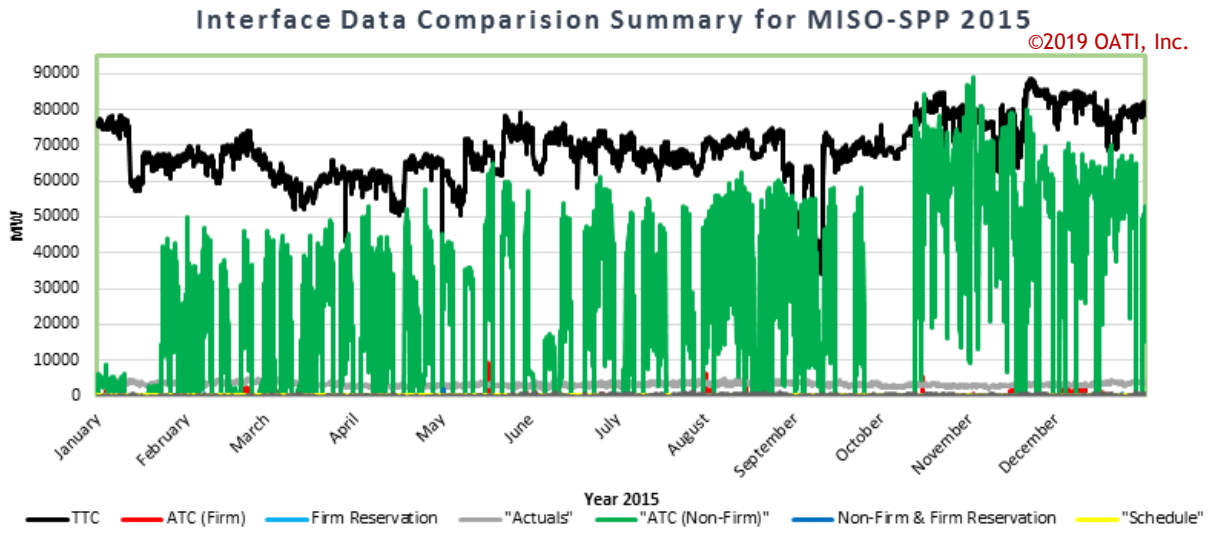


Figure 5.2-2t: Interface Comparison Summary for MISO > SPP

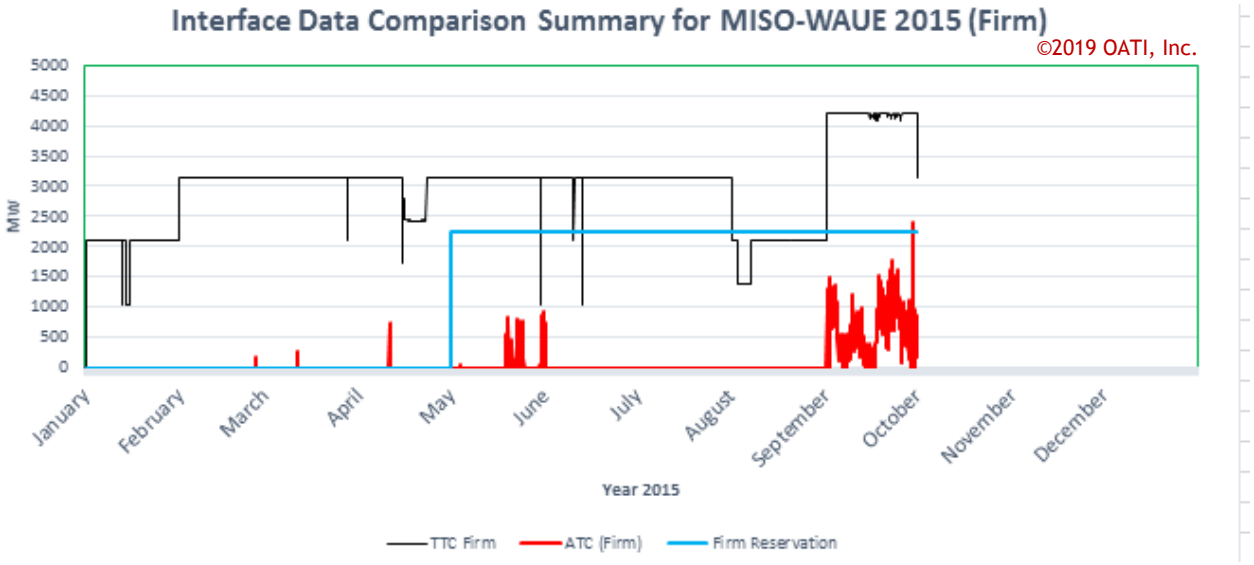


Figure 5.2-2u: Interface Firm OASIS Comparison Summary for MISO > WAUE

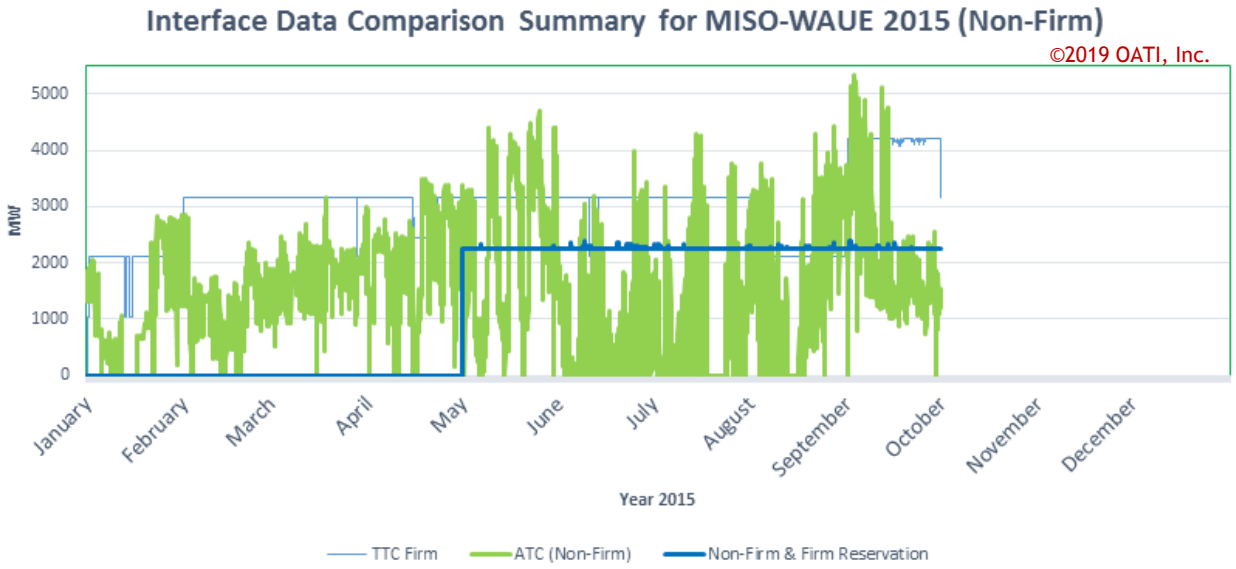


Figure 5.2-2v: Interface Non-Firm OASIS Comparison Summary for MISO > WAUE

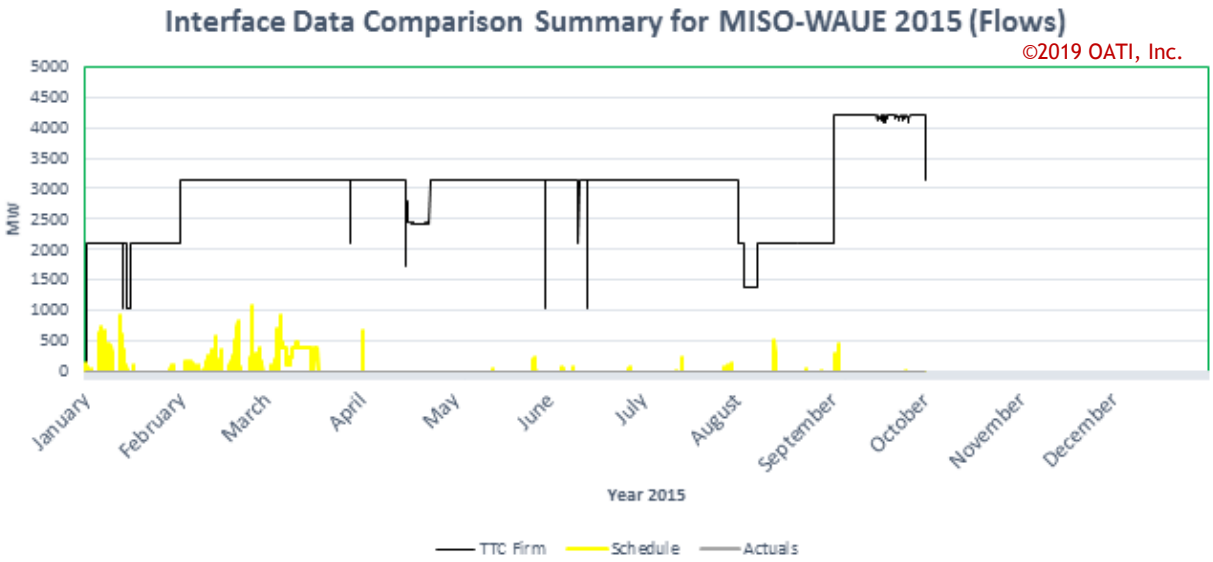


Figure 5.2-2w: Interface Flow Comparison Summary for MISO > WAUE

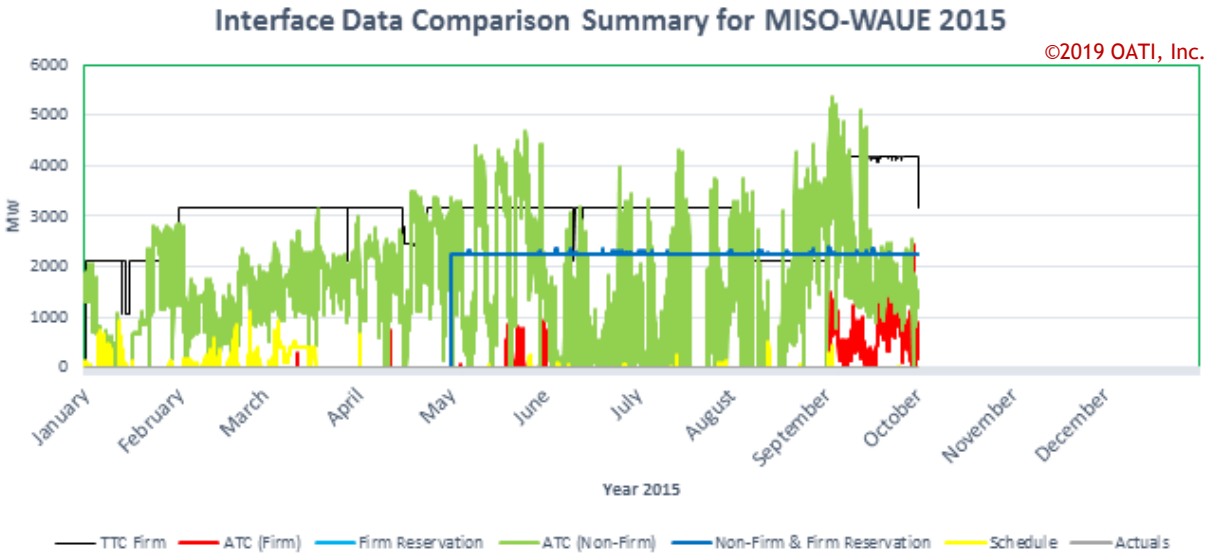


Figure 5.2-2x: Interface Comparison Summary for MISO > WAUE

5.2.4 MISO Study Metrics Summary

Both metrics for MISO sub-region and its interfaces between MISO and neighboring sub-regions are summarized in this section along with the study findings. Table 5.2-10a provides the interface summary related to MISO to visualize and compare its performance or limitations during reservations, scheduling and RT operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between MISO and other sub-regions. The top limiting flowgate for each interfaces due to zero ATC and TLR is also summarized in Table 5.2-10b. The highlighted flowgate in Table 5.2-10b represents the most limiting flowgate that limits MISO interfaces due to ATC or TLR.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule /Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
MISO > PJM	278/5508 (14395/1277)	**1708/3390 (178400/2440)**	86.00/37.5 **(92.53/65.64)**	**0/0**	**0/0**	7480/2359	0/7	0/3	0	**0/643**	**0/53016**	**0/1180**
PJM > MISO	323/10748 (1621/8557)	26/10 (N/A)	7.45/0.09 (N/A)	0/167	0/10	0/0	0/0	0/0	0	0/0	0/0	0/0
MISO > SPP	33/984 **(19880/254)**	9/444 (252/59)	21.43/31.09 (1.25/18.81)	0/0	0/0	8563/3061	0/0	0/0	0	0/0	0/0	0/0
SPP > MISO	23/0 (752/0)	51/34 (1074/295)	68.91/100 (58.5/100)	0/0	0/0	**8733/3242**	0/0	0/0	0	0/86	0/1839	0/178
MISO > TVA	17/149 (5454/39)	193/155 (2641/424)	**91.9/50.99** (32.63/91.56)	0/0	0/0	8493/4511	0/5	0/1	0	0/41	0/3523	0/79
TVA > MISO	6/29 (5428/3)	30/22 (1870/45)	83.33/13.13 (25.63/92.37)	0/0	0/0	8520/6	97/174	21/49	0	0/30	0/127	0/59
MISO > SOCO	9/275 (2826/48)	102/130 (1264/1264)	91.89/32.1 (30.91/96.30)	0/0	0/0	8440/1506	0/0	0/0	0	0/55	0/2522	0/110
SOCO > MISO	**942/254** (3396/22)	53/21 (228/2)	5.33/7.64 (6.31/11)	**683/0**	**347/0**	233/207	**608/26**	**287/4**	0	0/4	0/190	0/8
MISO > NON RTO MIDWEST	120/83 (447/45)	0/82 (0/100)	0/49.7 (100/68.72)	0/0	0/0	7363/299	0/1	0/1	0	0/25	0/815	0/51

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule /Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
NON RTO MIDWEST > MISO	22/1645 (365/162)	2/56 (1/4)	8.3/3.3 (3.14/2.72)	0/0	0/0	604/1182	0/0	0/0	0	0/35	0/979	0/76
MISO > WAUE	8/122 (13232/15)	0/79 (0/7)	0/39.3 (0/33.69)	0/0	0/0	5829/1003	0/0	0/0	0	0/90	0/6103	0/186
WAUE > MISO	*	*	*	*	*	*	*	*	*	*	*	*

Table 5.2-10a: - MISO Interface Summary

Top limiting flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
MISO > PJM	None	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	369
MISO > SPP	None	0	None	0
MISO > TVA	None	0	Widows Creek 500/161 bank flo Browns Ferry-Maury 500kv	61
MISO > SOCO	None	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	108
MISO > NON RTO MIDWEST	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	34
MISO > WAUE	None	0	TEMP05 Mandan - Dickenson 230 kV (flo) Antelope Valley - Charlie Creek 345 kV	72

Table 5.2-10b: MISO TLR top flowgates

Based on the above summary results, the following observations were noted.

1. The MISO-PJM interface is the most limiting MISO interface based on refused TSR count, TLR duration, MWh and count; The SPP-MISO is the most limiting interface based on Zero ATC count
2. The SOCO-MISO interface is the most reserved interface based on confirmed TSR count, TRU75 and 90 count and MISO-SPP interface is the most reserved interface based on the confirmed GWh.
3. The SOCO-MISO interface is the most loaded interface during RT in MISO based on U90 count (schedule).
4. No firm TLRs were called on interfaces from or to MISO; however, non-firm TLRs were called on almost all interfaces.
5. Top limiting TLR flowgate was Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR on the MISO-PJM interface.

MISO sub-region metrics are summarized below. Table 5.2-10c provides a TLR summary for the MISO sub-region. Table 5.2-10d provides the most limiting flowgate that limits the MISO sub-region due to ATC or TLR. Table 5.2-10e provides the most limiting binding constraint that limits the MISO sub-region during the RT market due to market flow.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
MISO	0/871	0/67348	0/1639

Table 5.2-10c: MISO TLR Sub-Region Summary

MISO	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	539

Table 5.2-10d: MISO Top Limiting Flowgate for TLR

MISO	Constraint Due to Count		Constraint Due to Cost	
	Binding Constraints Name	Market Binding Hour Count	Binding Constraints Name	Congestion Cost
Top Binding Constraint	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	1085	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	$6.3 M

Table 5.2-11e: Most Limiting Binding Constraints to the Market Flow Impacts

1. No firm TLRs were called on Interfaces in the MISO sub-region, however non-firm TLRs were called, and the Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR flowgate had the most TLRs called upon it.
2. In the MISO market, the most limiting binding constraint and most limiting MISO-owned binding constraint due to market flow for both was Oak_Grove_Mercer161_flo_Nelson_ElectricJct.
3. A separate comparison was performed which is included in Appendix D based on the DOE's Annual U.S. Transmission Data Review that published a list of the top future constraints observed in the MISO sub-region. Comparison of both results shows that there are no consistencies between the 2016 U.S. Transmission Data Review and OATI generated results. This is due to the fact that, as mentioned in this study, MISO was considered one single sub-region but in actuality, MISO, being spread out geographically over a large area, uses MISO North, South, and Central to represent their sub-region.

5.3 Non RTO Midwest

5.3.1 Sub-Region Metrics

5.3.1.1 TLR Metrics

This study developed TLR metrics for the Non RTO Midwest sub-region and identified the five most limiting TLR flowgates based on TLR counts.

Sub-region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
Non RTO Midwest	0	0	0	350	13269	748

Table 5.3-1a: TLR metrics for Non RTO Midwest Sub-region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
Non RTO Midwest	None	0	0	Pierce- Foster 345KV	361	4961
				Kyger Creek - Sporn 345kv tie line	121	1982
				TMP131 Lacygne - W. Gardner 345 kV (FLO) Lacygne - Stillwell 345 kV	60	2199
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	45	646
				Trimble Cty - Clifty Creek 345kV line for the loss of Jefferson - Rockport 765 kV line	39	1705

Table 5.3-1b: Top Five TLR Limiting Flowgates (Count Based) for Non RTO Midwest Sub-region

5.3.2 Interface Metrics

5.3.2.1 Transmission Service Request Metric

The results from the Transmission Service Request Metric for Non RTO Midwest interfaces are provided in Tables 5.3-2a through 5.3-2d. These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces.

Interface	Firm Confirmed TSR count	Firm Refused TSR count	% Refusal
NON RTO MIDWEST > MISO	22	2	8.33%
MISO > NON RTO MIDWEST	120	0	0.00%
NON RTO MIDWEST > PJM	6	0	0.00%
PJM > NON RTO MIDWEST	16	9	36.0%
NON RTO MIDWEST > TVA	19	17	47.2%
TVA > NON RTO MIDWEST	3	2	40.0%
NON RTO MIDWEST > SPP	19	4	17.4%
SPP > NON RTO MIDWEST	*	*	*

Table 5.3-2a: Firm Confirmed & Refused TSR count

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
NON RTO MIDWEST > MISO	1645	56	3.29%
MISO > NON RTO MIDWEST	83	82	49.70%
NON RTO MIDWEST > PJM	2093	109	4.95%
PJM > NON RTO MIDWEST	326	4	1.21%
NON RTO MIDWEST > TVA	96	20	17.24%
TVA > NON RTO MIDWEST	0	8	100.00%
NON RTO MIDWEST > SPP	2212	746	25.21%
SPP > NON RTO MIDWEST	*	*	*

Table 5.3-2b: Non-Firm Confirmed & Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
NON RTO MIDWEST > MISO	365279	1152	3.14
MISO > NON RTO MIDWEST	447790	0	0.00
NON RTO MIDWEST > PJM	1660997	0	0.00
PJM > NON RTO MIDWEST	7273704	NA	NA
NON RTO MIDWEST > TVA	7464	0	0.00
TVA > NON RTO MIDWEST	821926	3384	0.41
NON RTO MIDWEST > SPP	17323808	84000	0.48
SPP > NON RTO MIDWEST	*	*	*

Table 5.3-2c: Firm Confirmed & Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
NON RTO MIDWEST > MISO	162634	4552	2.72
MISO > NON RTO MIDWEST	45776	100578	68.72
NON RTO MIDWEST > PJM	250979	10205	3.91
PJM > NON RTO MIDWEST	28858	NA	NA
NON RTO MIDWEST > TVA	21108	4004	15.94
TVA > NON RTO MIDWEST	0	4220	100.00
NON RTO MIDWEST > SPP	475646	748850	61.15
SPP > NON RTO MIDWEST	*	*	*

Table 5.3-2d: Non-Firm Confirmed & Refused Reservation MWh

5.3.2.2 Transmission Reservation Utilization Metric

The results from the Transmission Service Utilization Metric for Non RTO Midwest interfaces are provided in Tables 5.3-3a and 5.3-3b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
NON RTO MIDWEST > MISO	0	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > PJM	0	0
PJM > NON RTO MIDWEST	0	0
NON RTO MIDWEST > TVA	0	0
TVA > NON RTO MIDWEST	0	0
NON RTO MIDWEST > SPP	0	0
SPP > NON RTO MIDWEST	*	*

Table 5.3-3a: TRU75 for Firm & Non-Firm Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
NON RTO MIDWEST > MISO	0	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > PJM	0	0
PJM > NON RTO MIDWEST	0	0
NON RTO MIDWEST > TVA	0	0
TVA > NON RTO MIDWEST	0	0
NON RTO MIDWEST > SPP	0	0
SPP > NON RTO MIDWEST	*	*

Table 5.3-3b: TRU90 for Firm & Non-Firm Reservation

5.3.2.3 Zero ATC Metrics

The results from ATC Metric for Non RTO Midwest interfaces are provided in Table 5.3-4.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
NON RTO MIDWEST > MISO	604	1182
MISO > NON RTO MIDWEST	7363	299
NON RTO MIDWEST > PJM	828	221
PJM > NON RTO MIDWEST	0	24
NON RTO MIDWEST > TVA	1280	130
TVA > NON RTO MIDWEST	8760	946
NON RTO MIDWEST > SPP	*	*
SPP > NON RTO MIDWEST	*	*

Table 5.3-4: Firm Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.3-1a through 5.3-1d).

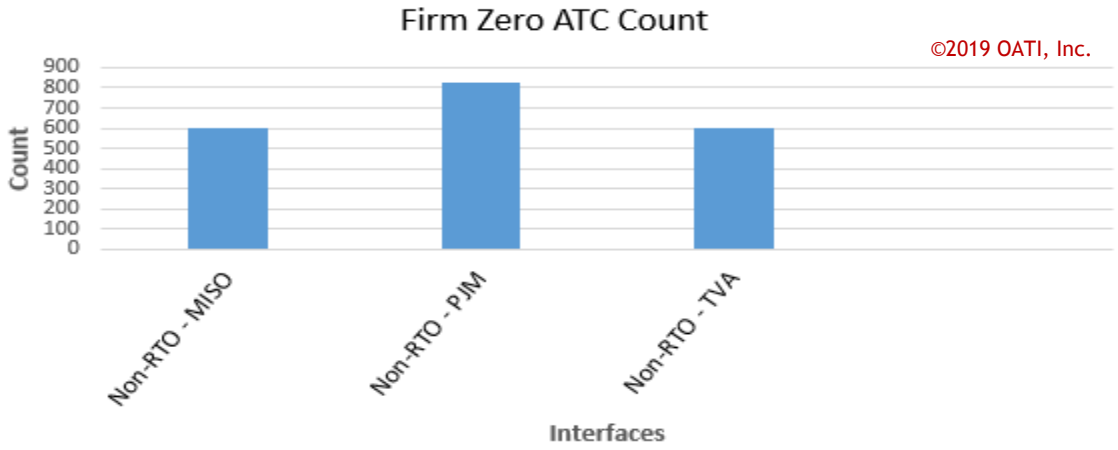


Figure 5.3-1a: Firm Zero ATC Count

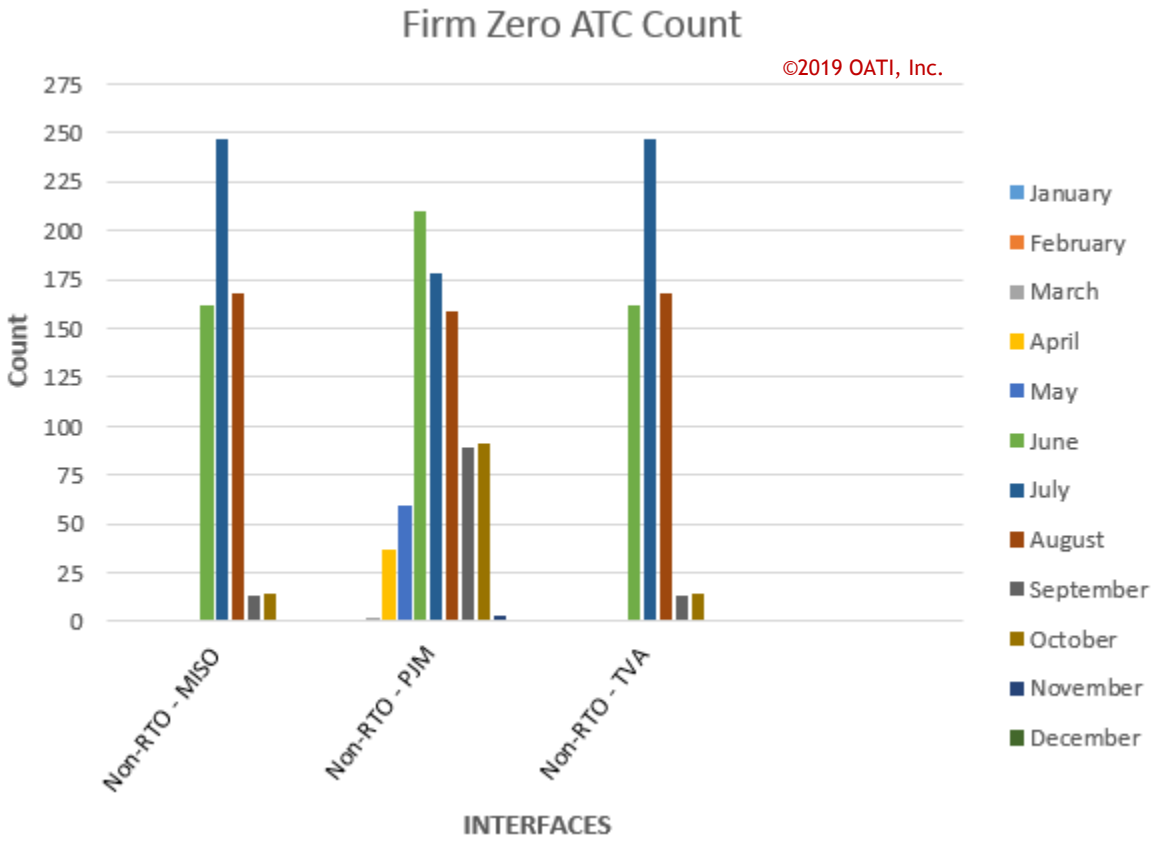


Figure 5.3-1b: Firm Zero ATC Count

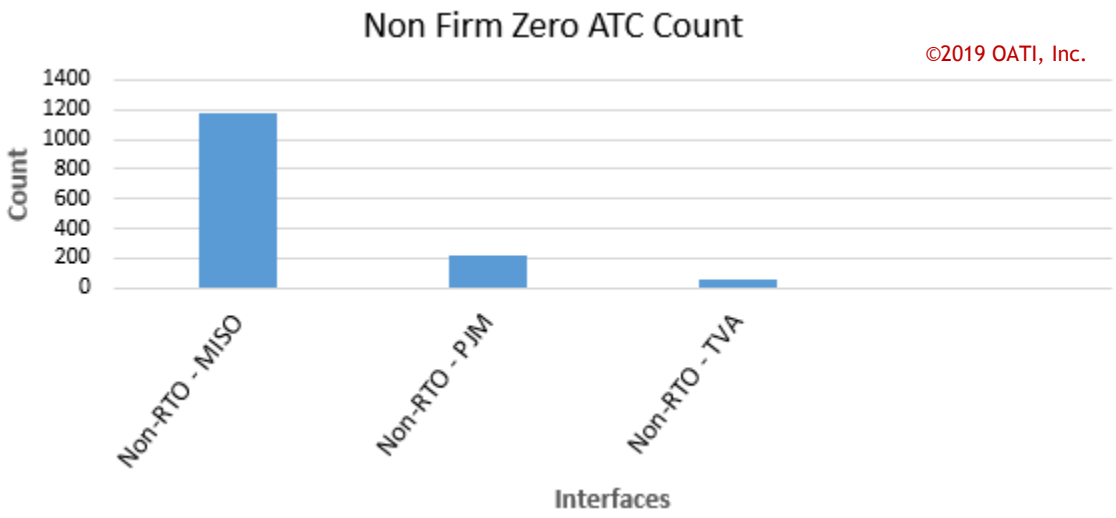


Figure 5.3-1c: Non-Firm Zero ATC Count

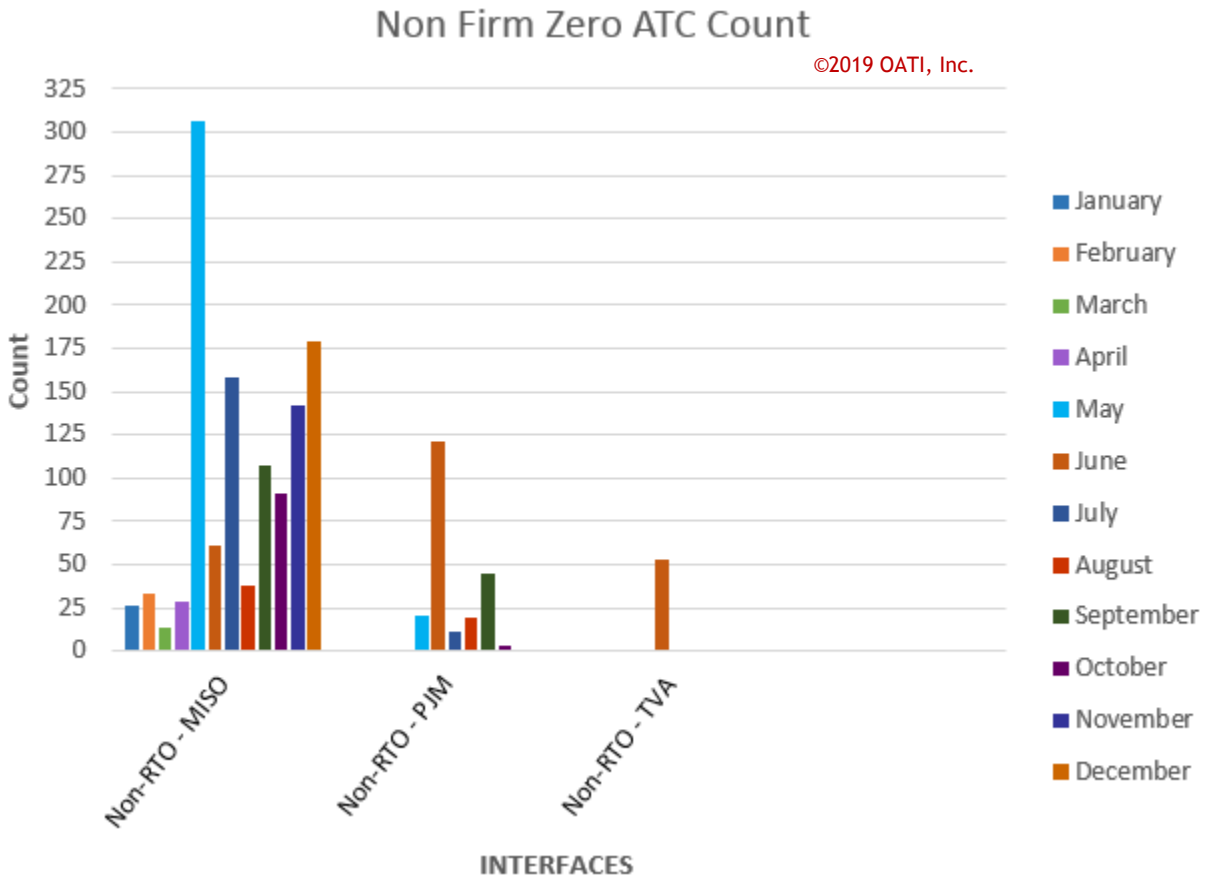


Figure 5.3-1d: Non-Firm Zero ATC Count

5.3.2.4 Schedule Utilization Metrics and Actual Flow Metrics

The results from the schedule utilization metrics and actual flow metrics for the Non RTO Midwest interfaces are provided in Table 5.3-5a and Table 5.3-5b.

Interface	U 75 Schedule Count	U 90 Schedule Count
NON RTO MIDWEST > MISO	0	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > PJM	0	0
PJM > NON RTO MIDWEST	0	0
NON RTO MIDWEST > TVA	0	0
TVA > NON RTO MIDWEST	0	0
NON RTO MIDWEST > SPP	0	0
SPP > NON RTO MIDWEST	*	*

Table 5.3-5a: Schedule flow Utilization Metric

Interface	U 75 Actual Count	U 90 Actual Count
NON RTO MIDWEST > MISO	0	0
MISO > NON RTO MIDWEST	0	0
NON RTO MIDWEST > PJM	0	0
PJM > NON RTO MIDWEST	0	0
NON RTO MIDWEST > TVA	0	0
TVA > NON RTO MIDWEST	0	0
NON RTO MIDWEST > SPP	0	0
SPP > NON RTO MIDWEST	*	*

Table 5.3-5b: Actual Flow Metric

Metrics for interfaces based on the schedule count above the TTC were also developed. The results for the metrics are provided in Table 5.3-5c.

Interface	Schedule Count above TTC
NON RTO MIDWEST > MISO	0
MISO > NON RTO MIDWEST	0
NON RTO MIDWEST > PJM	0
PJM > NON RTO MIDWEST	0
NON RTO MIDWEST > TVA	0
TVA > NON RTO MIDWEST	0
NON RTO MIDWEST > SPP	0
SPP > NON RTO MIDWEST	*

Table 5.3-5c: Schedule Count above TTC

5.3.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR Metric for the interfaces are provided in Tables 5.3-6a and Table 5.3-6b.

Interface	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
NON RTO MIDWEST > MISO	0	0	0	35	979	76
MISO > NON RTO MIDWEST	0	0	0	25	815	51
NON RTO MIDWEST > PJM	0	0	0	268	9810	579
PJM > NON RTO MIDWEST	0	0	0	0	0	0
NON RTO MIDWEST > TVA	0	0	0	29	171	14
TVA > NON RTO MIDWEST	0	0	0	10	174	20
NON RTO MIDWEST > SPP	0	0	0	64	2309	32
SPP > NON RTO MIDWEST	0	0	0	89	177	43

Table 5.3-6a: TLR metrics for NON RTO MIDWEST interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
NON RTO MIDWEST > MISO	None	0	0	Pierce- Foster 345KV	29	76
				Trimble Cty - Clifty Creek 345kV line for the loss of Jefferson - Rockport 765 kV line	26	791
				Kyger Creek - Sporn 345kv tie line	8	30
				OMU Smith 138/345 XFMR flo Wilson to Daviess 345	7	33
				GreenRivStl- Cloverport 138 kv FLO Davies-Smith 345 kv	4	46
NON RTO MIDWEST > PJM	None	0	0	Pierce- Foster 345KV	332	4886
				Kyger Creek - Sporn 345kv tie line	113	1952
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	45	646
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	23	127
				Kyger Creek - Sporn 345 kV l/o Jefferson - Hanging Rock 765 kV	21	183
NON RTO MIDWEST > TVA	None	0	0	None	0	0
NON RTO MIDWEST > SPP	None	0	0	TMP131 Lacygne - W. Gardner 345 kV (FLO) Lacygne - Stillwell 345 kV	60	2199
				Freeport - Twinkletown 230 flo Freeport - Hornlake 230	3	0.83
				Moberly_Overton_161kV_flo_ Thomas_Hill_McCredie_Kingdom_City_345kV	1	108.33

Table 5.3-6b: Top Five Limiting Flowgates (Count Based) for NON RTO MIDWEST Interfaces

5.3.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and schedule flow for the whole year for all the MISO interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, schedule flow, and TTC. The fourth graph is a combination of all parameters.

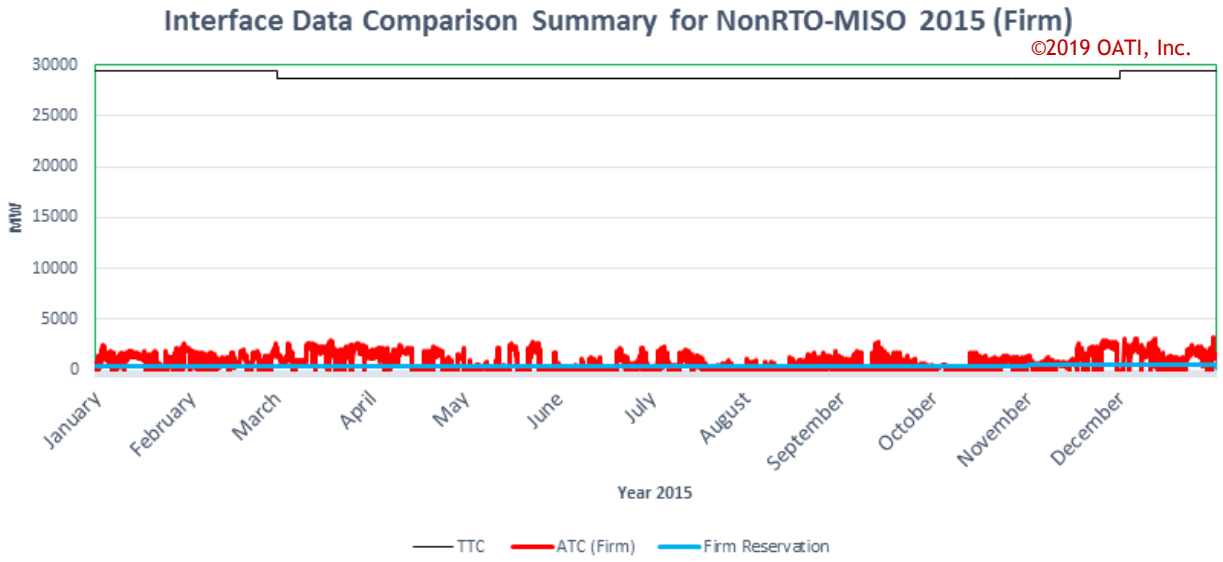


Figure 5.3-2a: Interface Firm OASIS Comparison Summary for Non RTO Midwest > MISO

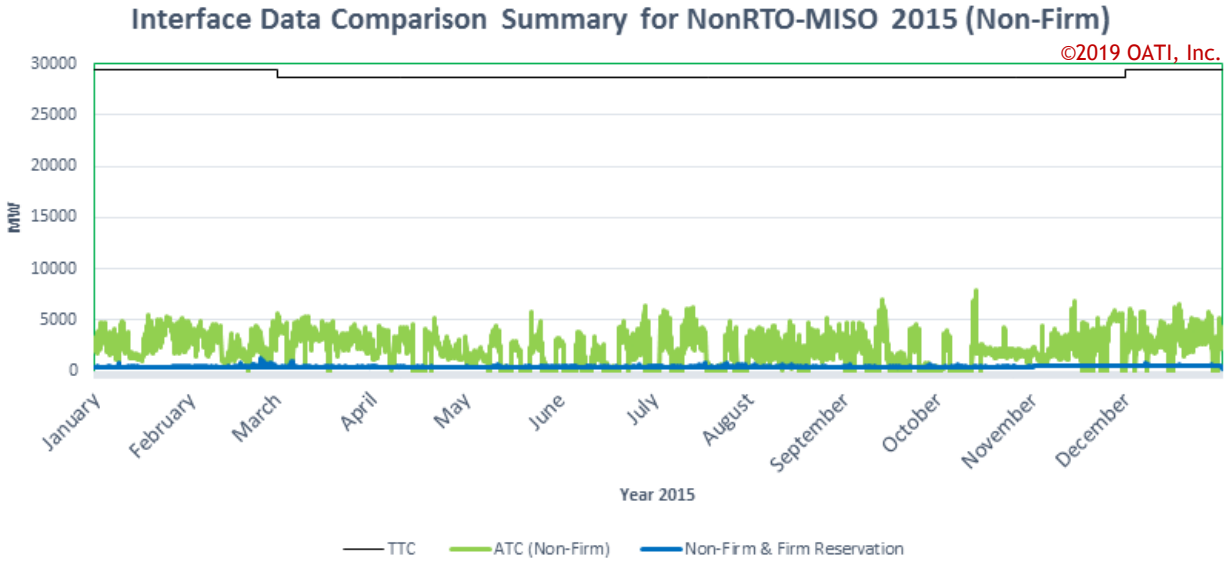


Figure 5.3-2b: Interface Non-Firm OASIS Comparison Summary for Non RTO Midwest > MISO

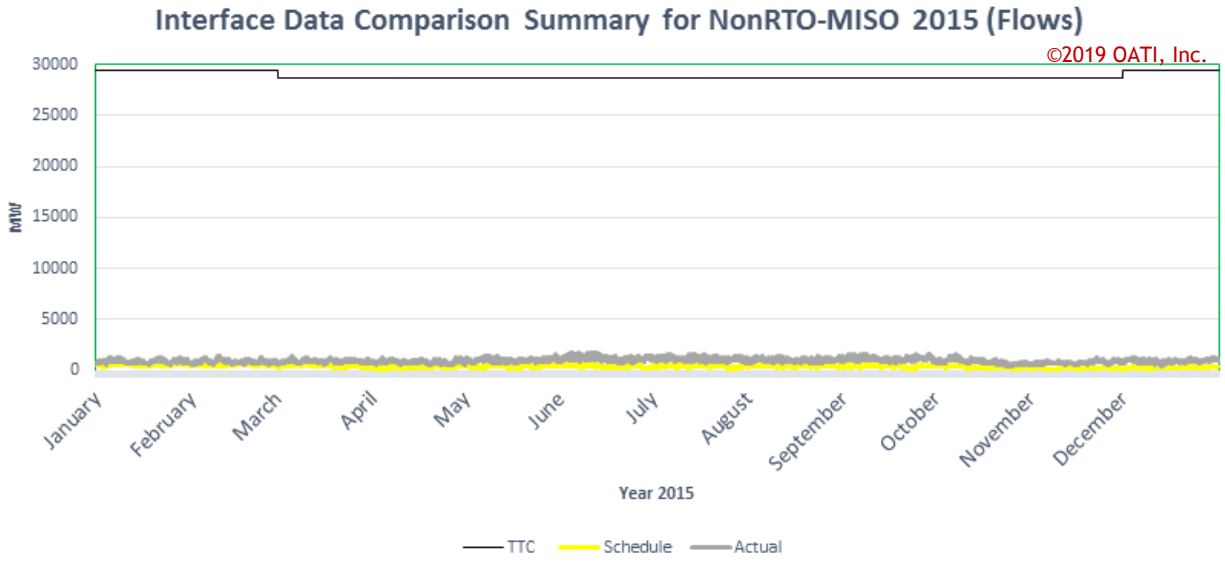


Figure 5.3-2c: Interface Flow Comparison Summary for Non RTO Midwest > MISO

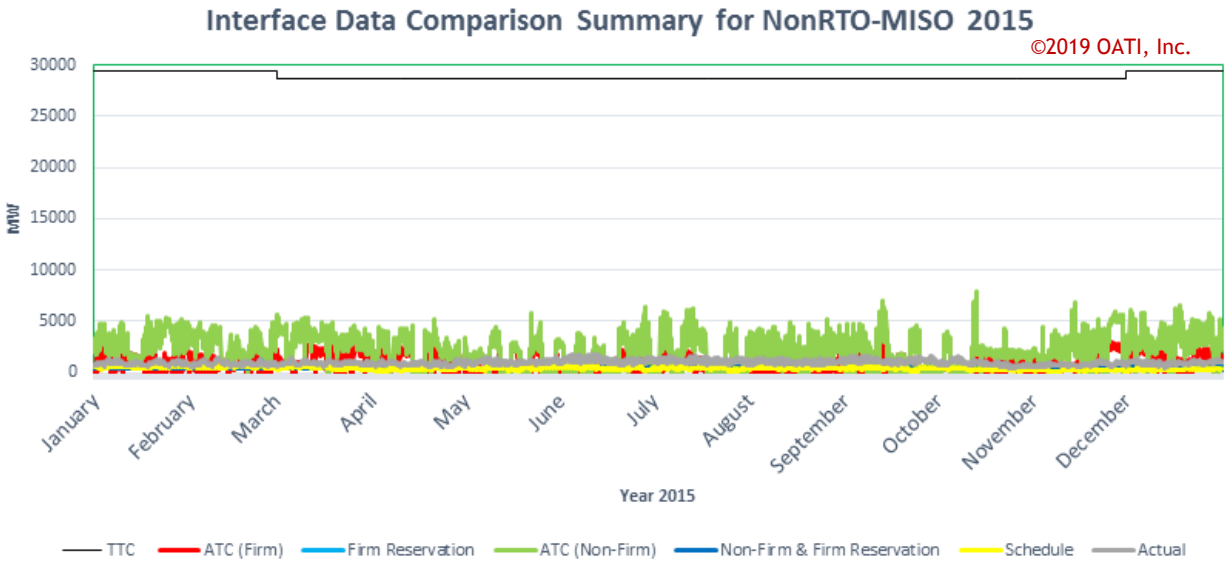


Figure 5.3-2d: Interface Comparison Summary for Non RTO Midwest > MISO

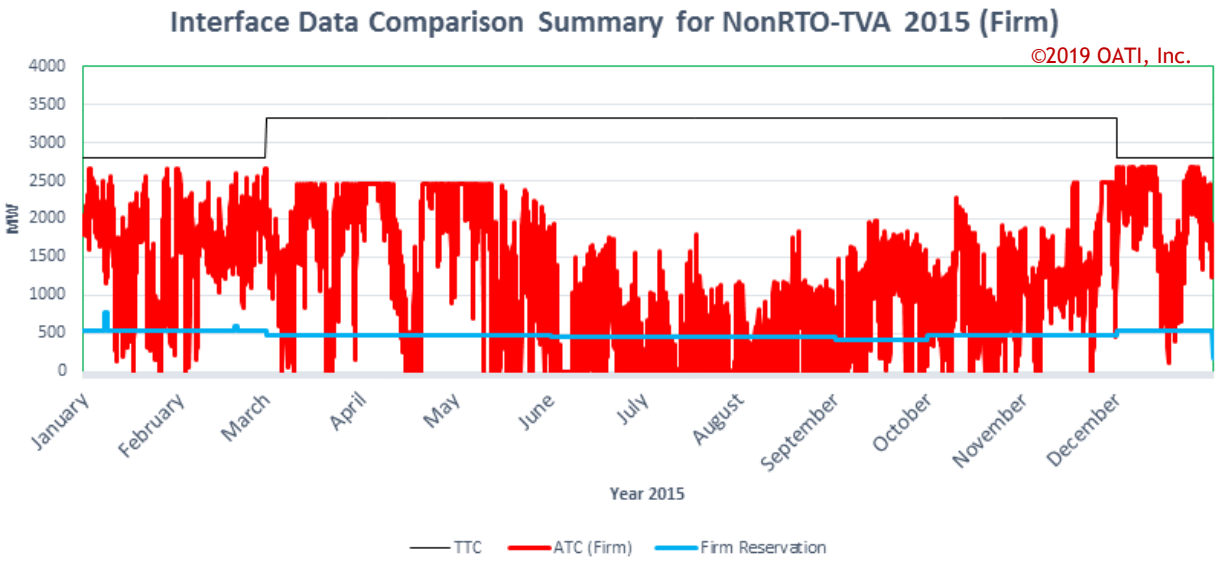


Figure 5.3-2e: Interface Firm OASIS Comparison Summary for Non RTO Midwest > TVA

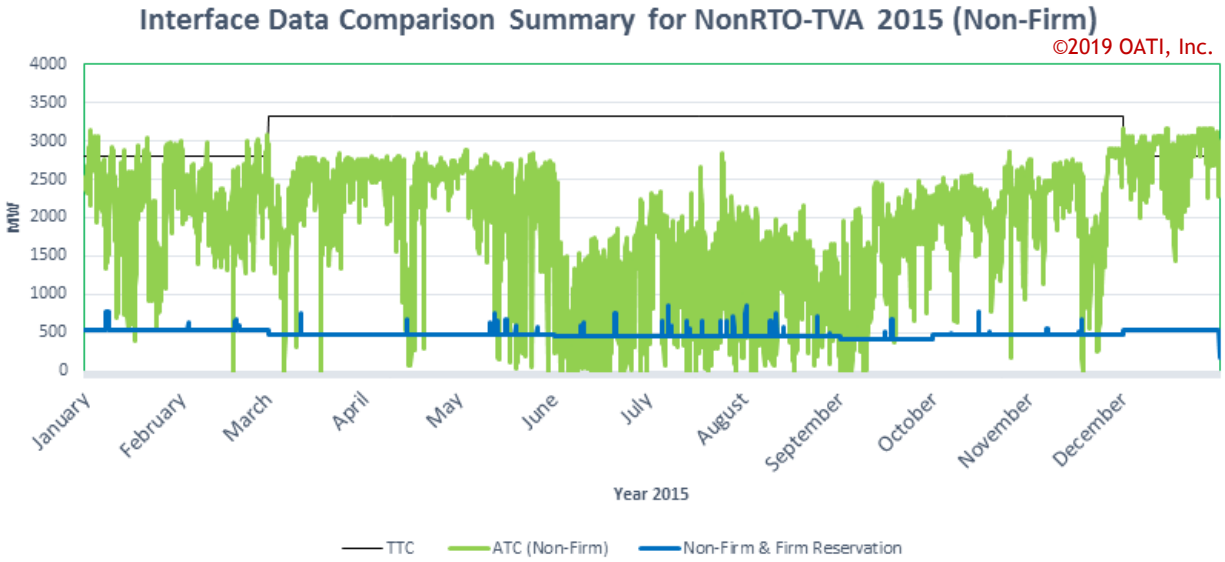


Figure 5.3-2f: Interface Non-Firm OASIS Comparison Summary for Non RTO Midwest > TVA

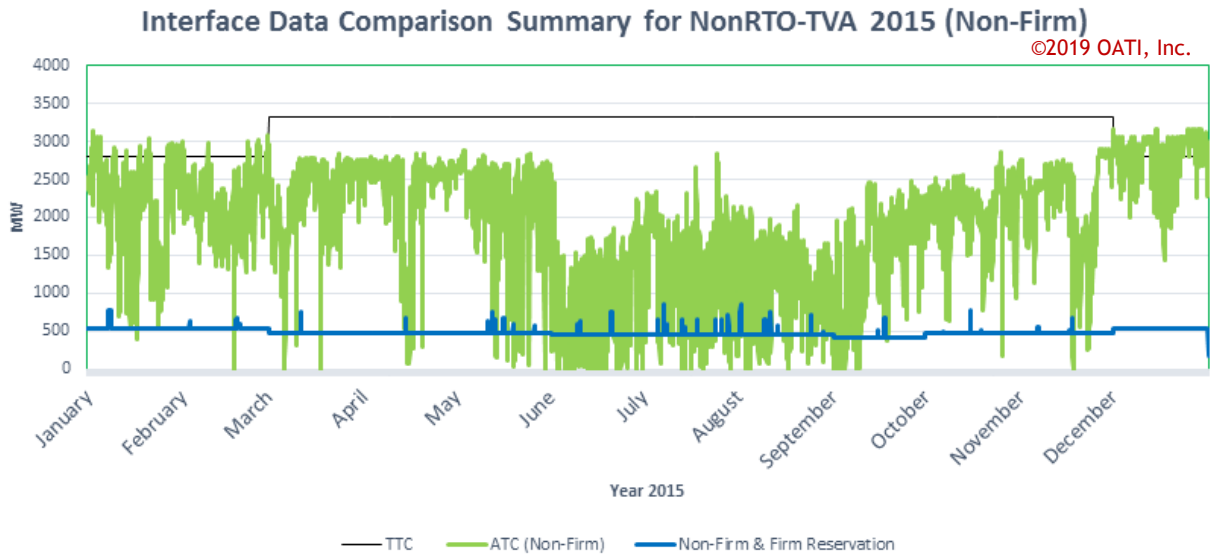


Figure 5.3-2g: Interface Flow Comparison Summary for Non RTO Midwest > TVA

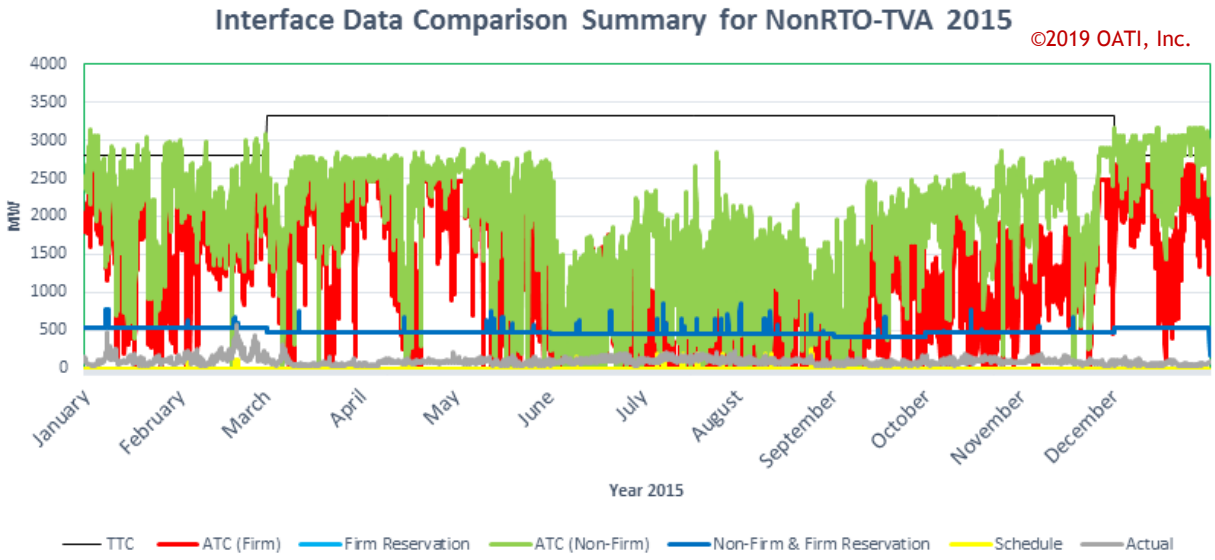


Figure 5.3-2h: Interface Comparison Summary for Non RTO Midwest > TVA

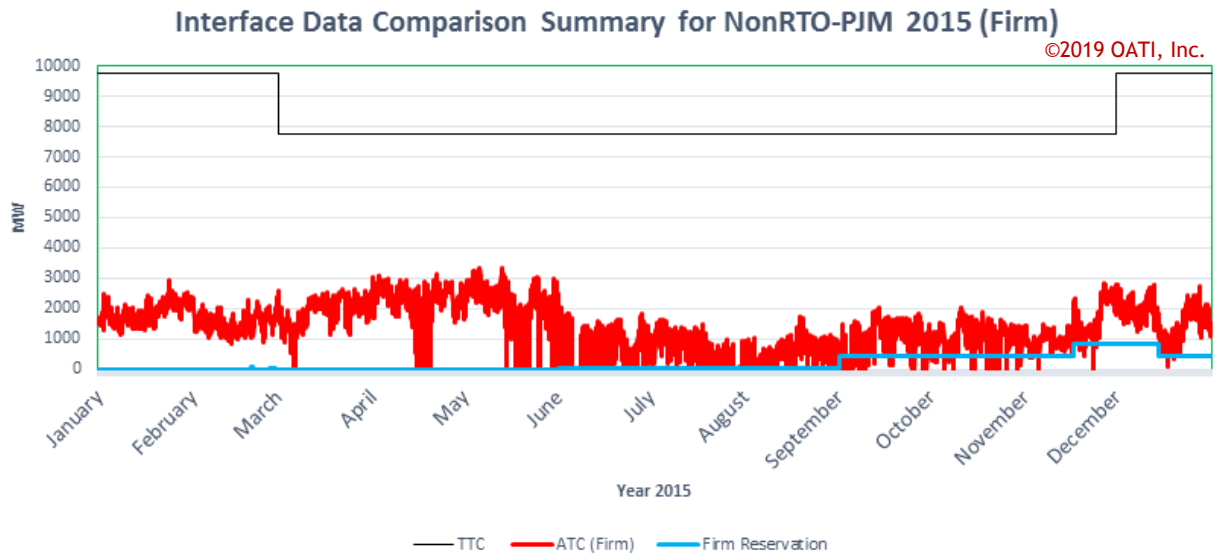


Figure 5.3-2i: Interface Firm OASIS Comparison Summary for Non RTO Midwest > PJM

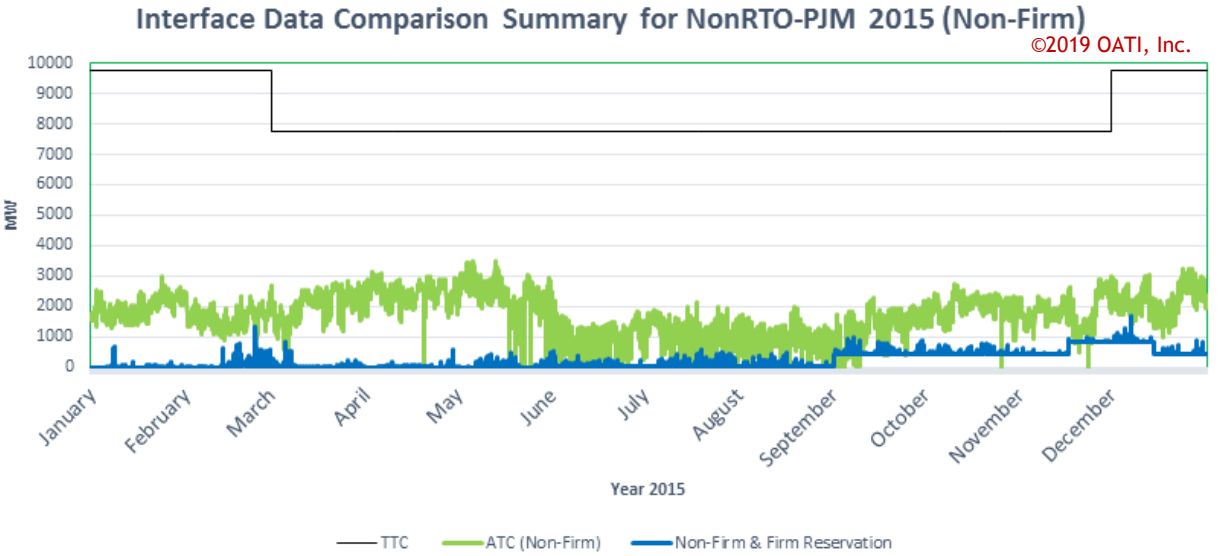


Figure 5.3-2j: Interface Non-Firm OASIS Comparison Summary for Non RTO Midwest > PJM

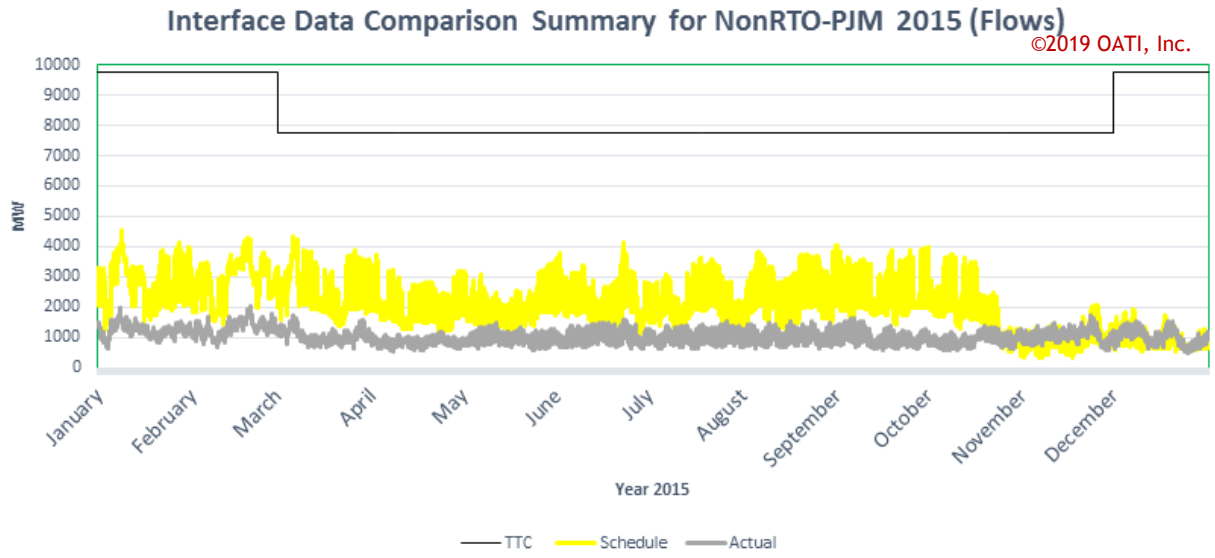


Figure 5.3-2k: Interface Flow Comparison Summary for Non RTO Midwest > PJM

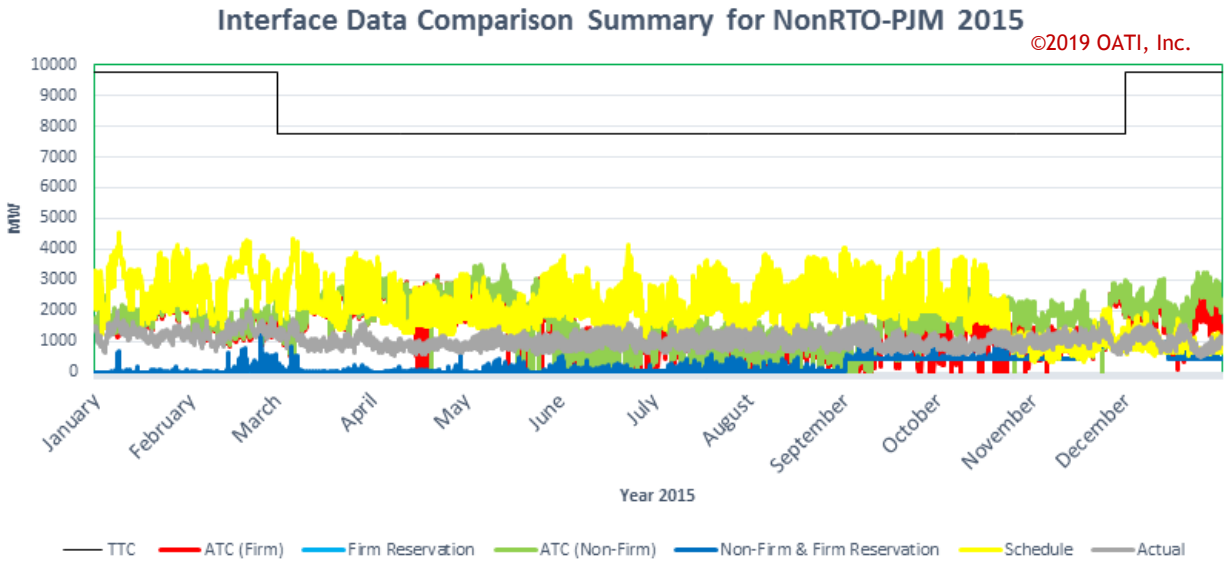


Figure 5.3-2l: Interface Comparison Summary for Non RTO Midwest > PJM

5.3.4 Non RTO Midwest Study Metrics Summary

Both metrics for Non RTO Midwest sub-region and its interfaces between Non RTO Midwest and neighboring sub-regions are summarized in this section along with the study findings. Table 5.3-7a provides the interface summary related to Non RTO Midwest to visualize and compare its performance or limitations during reservations, scheduling and real-time operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between Non RTO Midwest and other sub-regions. The top limiting flowgate for each interfaces due to TLR is also summarized in Table 5.3-7b. Also, highlighted flowgate in Table 5.3-7b represents the most limiting flowgate that limits Non RTO Midwest interfaces due to TLR.

Interface	Confirmed TSR Count (Reservation GWh): Firm /Non-Firm	Refused TSR Count (Reservation GWh): Firm /Non-Firm	% Refusal TSR Count (Reservation GWh): Firm /Non-Firm	TRU75 Yearly Count: Firm /Non-Firm	TRU90 Yearly Count: Firm /Non-Firm	Zero ATC Yearly Count: Firm /Non-Firm	U 75 Schedule/ Actual Yearly Count	U 90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm /Non-Firm (Hours)	Yearly TLR MWh: Firm /Non-Firm	Yearly TLR Count: Firm /Non-Firm
NON RTO MIDWEST > MISO	22/1645 (365/162)	2/56 (1/4)	8.3/3.3 (3.14/2.72)	0/0	0/0	604/1182	0/0	0/0	0	0/35	0/979	0/76
MISO > NON RTO MIDWEST	**120/83** (447/45)	0/82 (0/100)	0/49.7 (0/68.72)	0/0	0/0	7363/299	0/0	0/0	0	0/25	0/815	0/51
NON RTO MIDWEST > PJM	6/2093 (1661/251)	0/109 (0/11)	0/4.95 (0/3.9)	0/0	0/0	828/221	0/0	0/0	0	**0/268**	**0/9810**	**0/579**
PJM > NON RTO MIDWEST	16/326 (7274/29)	9/4 (NA/NA)	36/1.21 (NA/NA)	0/0	0/0	0/24	0/0	0/0	0	0/0	0/0	0/0
NON RTO MIDWEST > TVA	19/96 (7/21)	17/20 (0/4)	**47.2/17.24** (0/15.94)	0/0	0/0	1280/130	0/0	0/0	0	0/29	0/171	0/14
TVA > NON RTO MIDWEST	3/0 (821/0)	2/8 (3/4)	40/100 **(0.41/100)**	0/0	0/0	**8760/946**	0/0	0/0	0	0/10	0/174	0/20
NON RTO MIDWEST > SPP	19/2212 (**17323/475**)	**4/746 (84/748)**	17.4/25.2 (0.48/61.15)	0/0	0/0	*	0/0	0/0	0/0	0/64	0/2309	0/32
SPP > NON RTO MIDWEST	*	*	*	*	*	*	*	*	*	0/89	0/177	0/43

Table 5.3-7a: Non RTO Midwest Interface Summary

Top limiting flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
NON RTO MIDWEST > MISO	None	0	Pierce- Foster 345KV	29
NON RTO MIDWEST > PJM	None	0	Pierce- Foster 345KV	332
NON RTO MIDWEST > TVA	None	0	None	0
NON RTO MIDWEST > SPP	None	0	TMP131 Lacygne - W. Gardner 345 kV (FLO) Lacygne - Stillwell 345 kV	60

Table 5.3-7b: Non RTO Midwest TLR Top Flowgates

Based on the above summary results the following observations are noted.

1. The Non RTO Midwest-PJM interface is the one of the most limiting interface in Non RTO Midwest based on TLR duration, TLR MWh and TLR count; the TVA-Non RTO Midwest interface is the most limiting interface based on Zero ATC count
2. The Non RTO Midwest-SPP interface is the most reserved interface based on confirmed TSR reservation GWh.
3. No firm TLRs were called on Interfaces from or to Non RTO Midwest however, non-firm TLRs were called on almost all interfaces.
4. Top limiting TLR flowgate is 'Pierce- Foster 345KV' which is present on Non RTO Midwest's interfaces with both PJM and MISO.

Non RTO Midwest sub-region metrics are summarized below. Table 5.3-7c provides TLR summary for Non RTO Midwest sub-region. Table 5.3-7d provides the most limiting flowgate that limits Non RTO Midwest sub region due to TLR.

Sub-Region	Yearly TLR Duration: Firm /Non-Firm (Hours)	Yearly TLR MWh: Firm /Non-Firm	Yearly TLR Count: Firm /Non-Firm
Non RTO Midwest	0/350	0/13269	0/748

Table 5.3-7c: - Non RTO Midwest TLR Sub-Region Summary

Non RTO Midwest	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	Pierce- Foster 345KV	361

Table 5.3-7d: Non RTO Midwest top limiting flowgate for TLR

No firm TLRs were called on Interfaces in a Non RTO Midwest sub-region however, non-firm TLRs were called and the Pierce- Foster 345KV flowgate had most TLR upon it.

5.4 VACAR

5.4.1 Sub-Region Metrics

5.4.1.1 TLR Metrics

This study developed TLR metrics for the VACAR sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

Sub-region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
VACAR	0	0	0	182	16608	351

Table 5.4-1a: TLR Metrics for VACAR Sub-region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
VACAR	None	0	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	227	9100
				Person-Halifax 230 kV line	43	497
				Greenville-Everetts 230kV l/o Edgecomb-Rocky Mount 230kV	31	753
				Greenville-Everetts 230kV Line l/o Bath County-Valley 500kV Line	23	5220
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	18	387

Table 5.4-1b: Top Five Limiting Flowgates (Count-Based) for the PJM Sub-region

5.4.2 Interface Metrics

5.4.2.1 Transmission Service Request Metric

These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces. The results from the TSR metric for the VACAR interfaces are provided in Tables 5.4-2a through 5.4-2d.

Interface	Firm Confirmed TSR count	Firm Refused TSR count	% Refusal
VACAR > PJM	218	10	4.39%
PJM > VACAR	1	0	0.00%
VACAR > SOCO	263	10	3.66%
SOCO > VACAR	3121	79	2.46%
VACAR > TVA	3	0	0.00%
TVA > VACAR	55	59	51.75%

Table 5.4-2a: Firm Confirmed and Refused TSR count

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
VACAR > PJM	3256	52	1.57%
PJM > VACAR	136	0	0.00%
VACAR > SOCO	3752	8	0.21%
SOCO > VACAR	175	1	0.56%
VACAR > TVA	66	2	2.94%
TVA > VACAR	14	8	36.36%

Table 5.4-2b: Non-Firm Confirmed and Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
VACAR > PJM	858524	451776	34.48
PJM > VACAR	3301824	NA	NA
VACAR > SOCO	760938	169896	18.25
SOCO > VACAR	13900708	2071275	12.97
VACAR > TVA	8880	0	0.00
TVA > VACAR	738868	899370	54.90

Table 5.4-2c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
VACAR > PJM	1238917	149088	10.74
PJM > VACAR	1304112	NA	NA
VACAR > SOCO	1129995	1574	0.14
SOCO > VACAR	20548	159635	88.60
VACAR > TVA	22875	82	0.36
TVA□ VACAR	17906	5378363	99.67

Table 5.4-2d: Non-Firm Confirmed and Refused Reservation MWh

5.4.2.2 Transmission Reservation Utilization Metric

The results from Transmission Service Utilization Metric for the VACAR interfaces are provided in Tables 5.4-3a and 5.4-3b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
VACAR > PJM	0	0
PJM > VACAR	0	0
VACAR > SOCO	0	0
SOCO > VACAR	97	0
VACAR > TVA	0	0
TVA > VACAR	222	24

Table 5.4-3a: TRU75 for Firm and Non-Firm Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
VACAR > PJM	0	0
PJM > VACAR	0	0
VACAR > SOCO	0	0
SOCO > VACAR	40	0
VACAR > TVA	0	0
TVA > VACAR	24	0

Table 5.4-3b: TRU90 for Firm and Non-Firm Reservation

5.4.2.3 Zero ATC Metrics

The results from the ATC Metric for VACAR interfaces are provided in Table 5.4-4.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
VACAR > PJM	208	174
PJM > VACAR	576	54
VACAR > SOCO	0	0
SOCO > VACAR	9	6
VACAR > TVA	400	171
TVA > VACAR	8568	170

Table 5.4-4: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.4-1a through 5.4-1d).

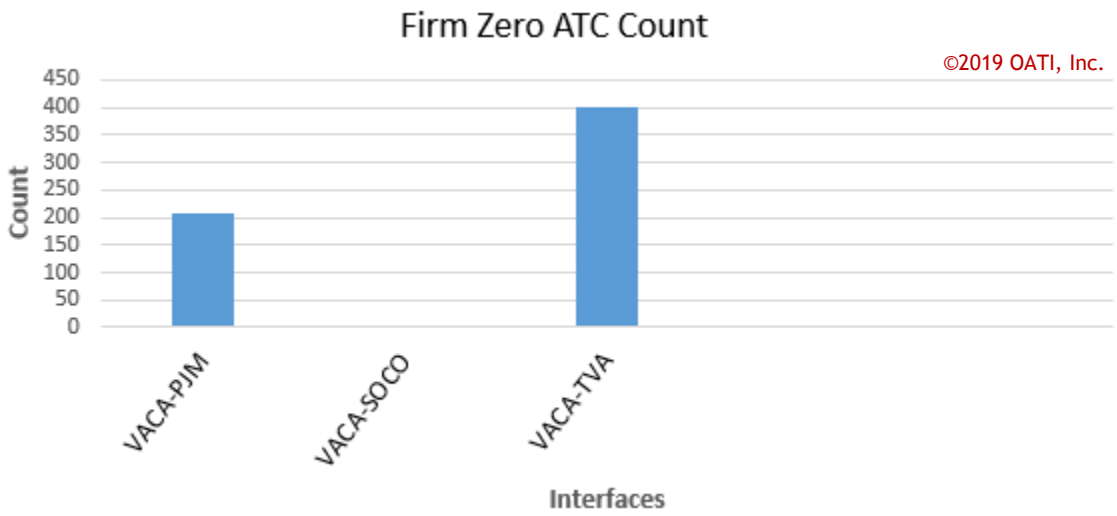


Figure 5.4-1a: Firm Zero ATC Count

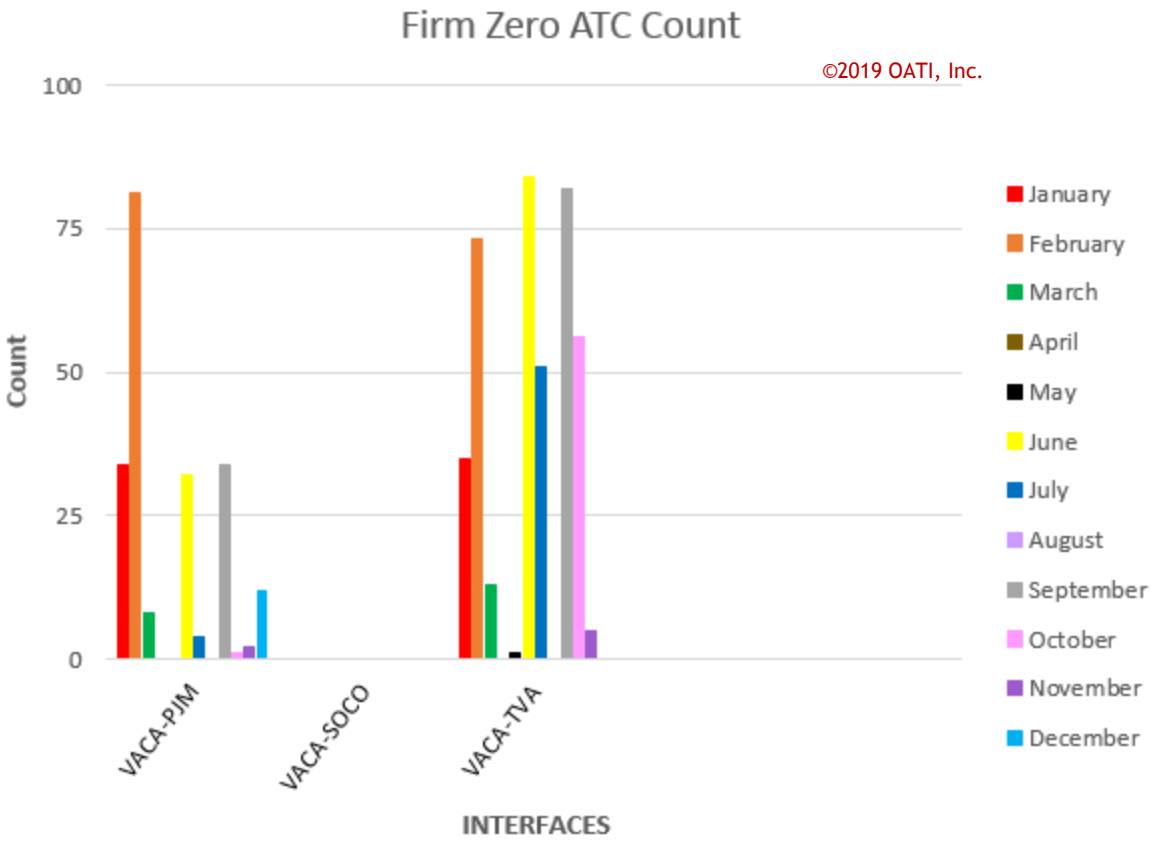


Figure 5.4-1b: Firm Zero ATC Count

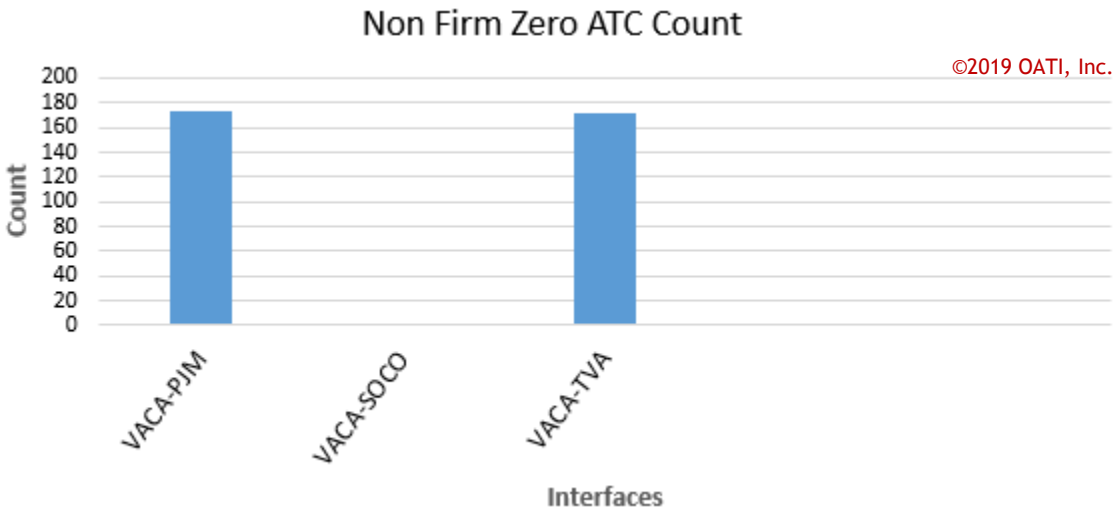


Figure 5.4-1c: Non-Firm Zero ATC Count

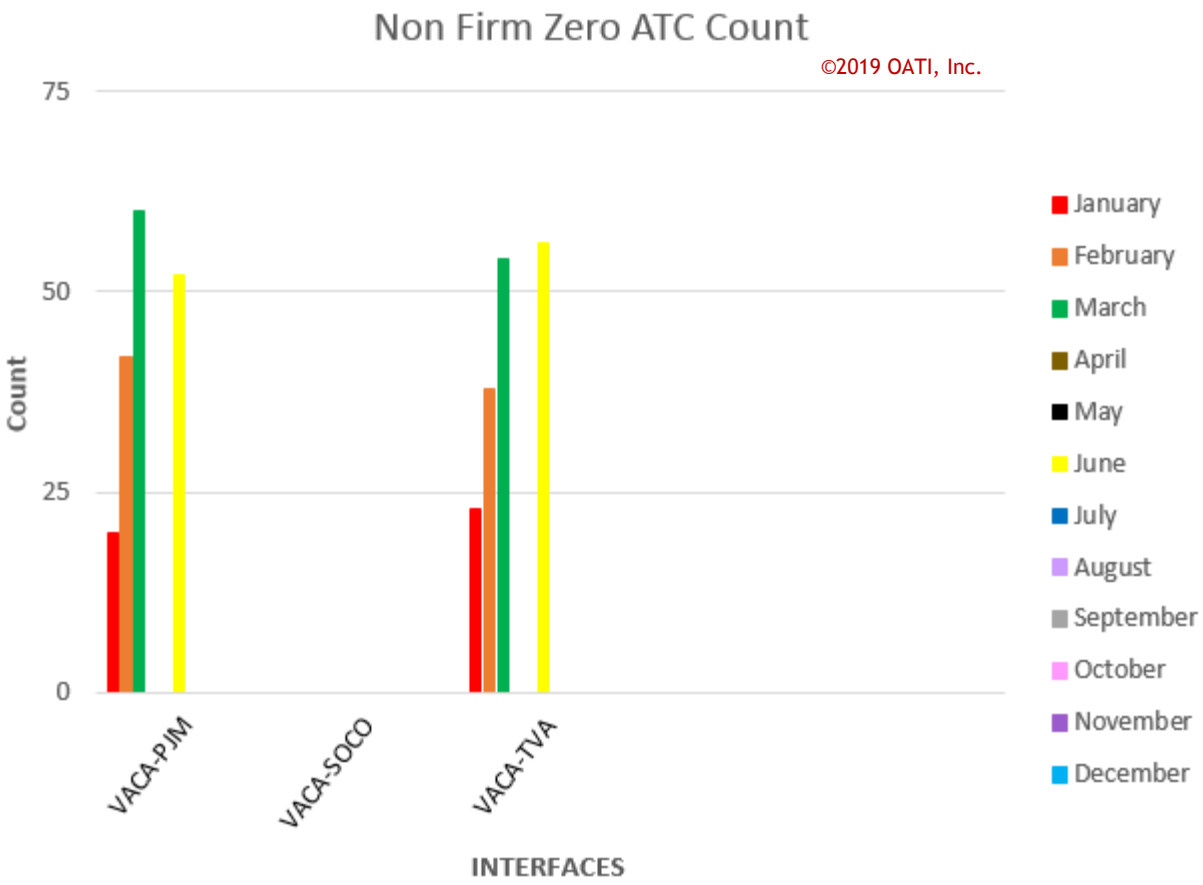


Figure 5.4-1d: Non-Firm Zero ATC Count

5.4.2.4 Schedule Utilization Metrics and Actual Flow Metrics

The results from the schedule utilization metrics and actual flow metrics for the VACAR interfaces are provided in Tables 5.4-5a through Table 5.4-5d.

Interface	U75 Schedule Count	U90 Schedule Count
VACAR□PJM	294	85
PJM□ VACAR	0	0
VACAR□SOCO	0	0
SOCO□ VACAR	0	0
VACAR□TVA	0	0
TVA□ VACAR	2451	838

Table 5.4-5a: Scheduled flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
VACAR > PJM	556	329
PJM > VACAR	0	0
VACAR > SOCO	0	0
SOCO > VACAR	19	15
VACAR > TVA	0	0
TVA > VACAR	0	0

Table 5.4-5b: Actual Flow Utilization Metric

Metrics for interfaces based on the schedule count above the TTC were also developed. The results for the metrics are provided in Table 5.4-5c.

Interface	Schedule Count above TTC
VACAR > PJM	0
PJM > VACAR	0
VACAR > SOCO	0
SOCO > VACAR	0
VACAR > TVA	0
TVA > VACAR	447

Table 5.4-5c: Schedule Count above TTC

5.4.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metric for the interfaces are provided in Tables 5.4-6a and 5.4-6b.

Interface	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
VACAR > PJM	0	0	0	181	22476	350
PJM > VACAR	0	0	0	245	29804	23
VACAR > SOCO	0	0	0	0	0	0
SOCO > VACAR	0	0	0	161	4939	261
VACAR > TVA	0	0	0	0.43	33	1
TVA > VACAR	0	0	0	7	1203	13

Table 5.4-6a: TLR Metrics for VACAR Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
VACAR > PJM	None	0	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	226	9066
				Person-Halifax 230 kV line	39	497
				Greenville-Everetts 230kV l/o Edgecomb-Rocky Mount 230kV	30	753
				Greenville-Everetts 230kV Line l/o Bath County-Valley 500kV Line	23	5220
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	16	387
VACAR > SOCO	None	0	0	None	0	0
VACAR > TVA	None	0	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	1	0.4

Table 5.4-6b: Top Five Limiting Flowgates (Count-Based) for VACAR Interfaces

5.4.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual versus scheduled flow for the whole year for all the MISO interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

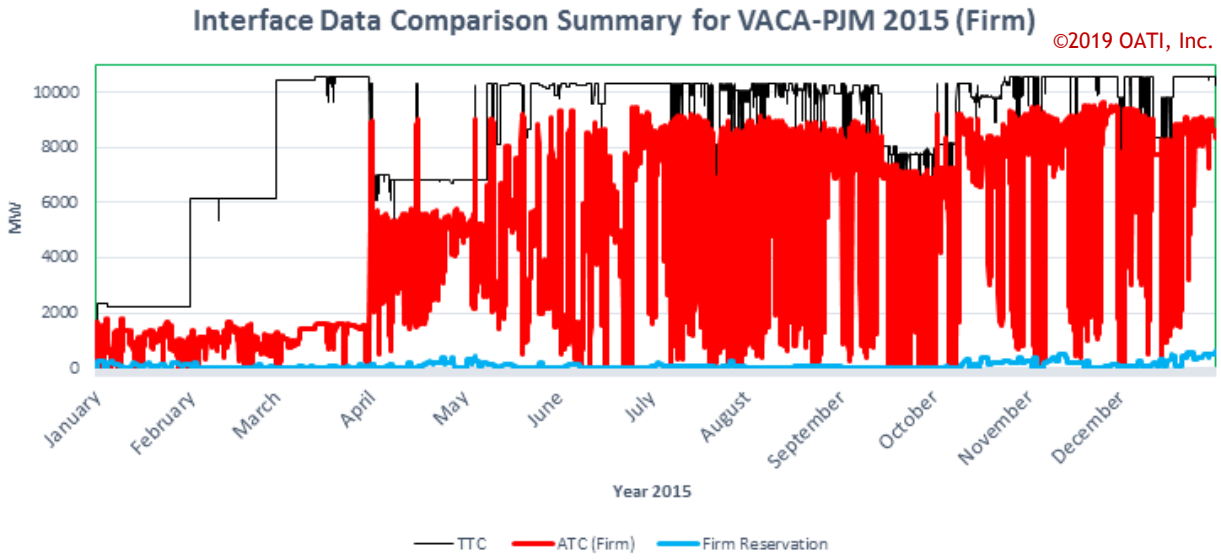


Figure 5.4-2a: Interface Firm OASIS Comparison Summary for VACAR > PJM

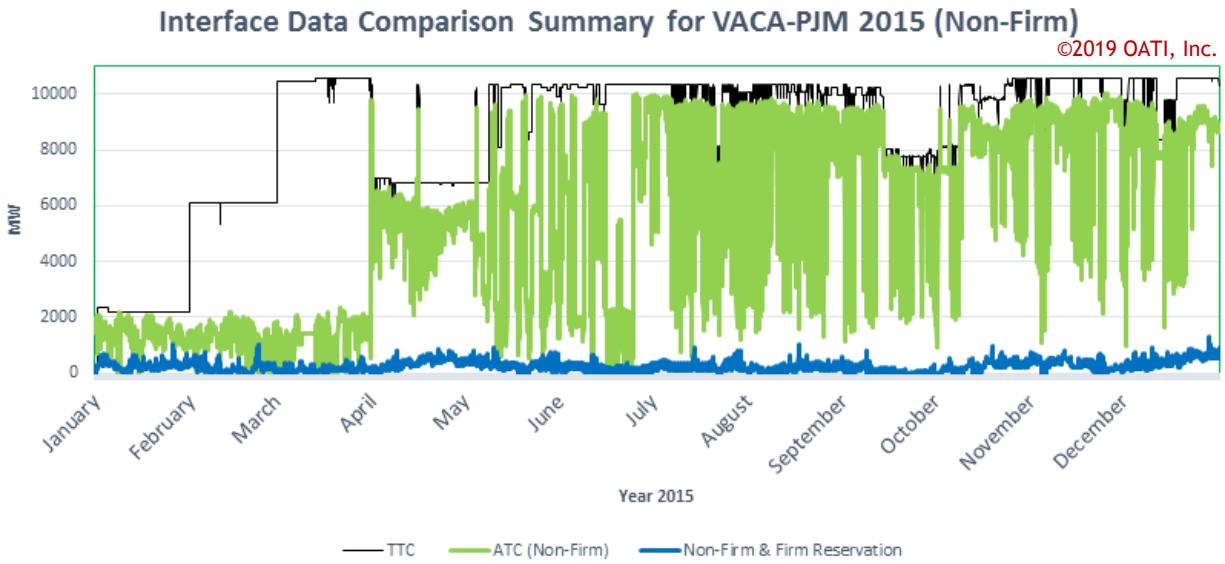


Figure 5.4-2b: Interface Non-Firm OASIS Comparison Summary for VACAR > PJM

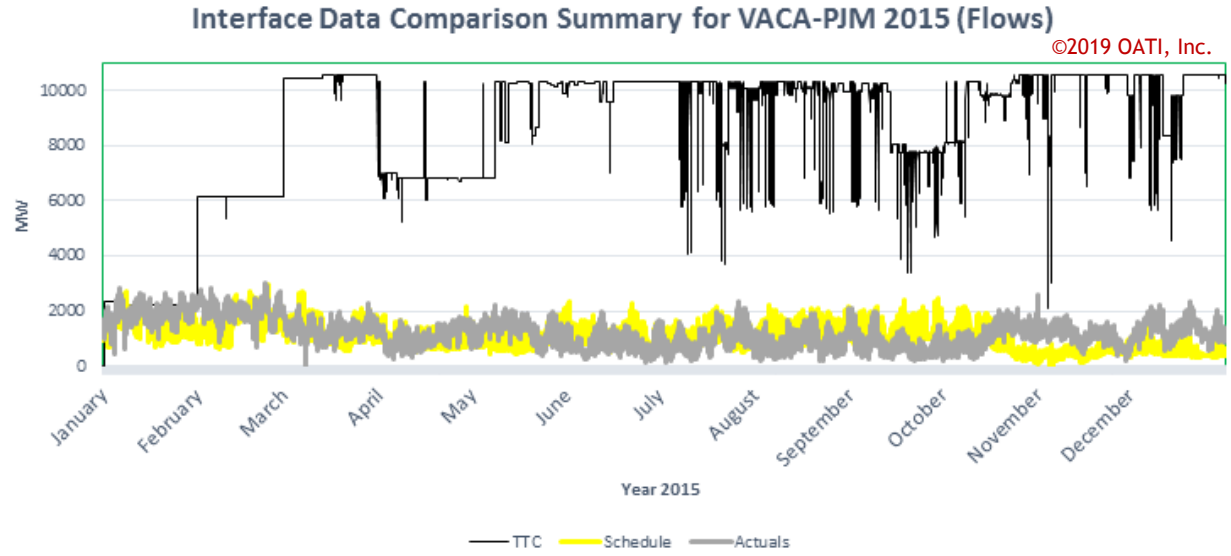


Figure 5.4-2c: Interface Flow Comparison Summary for VACAR > PJM

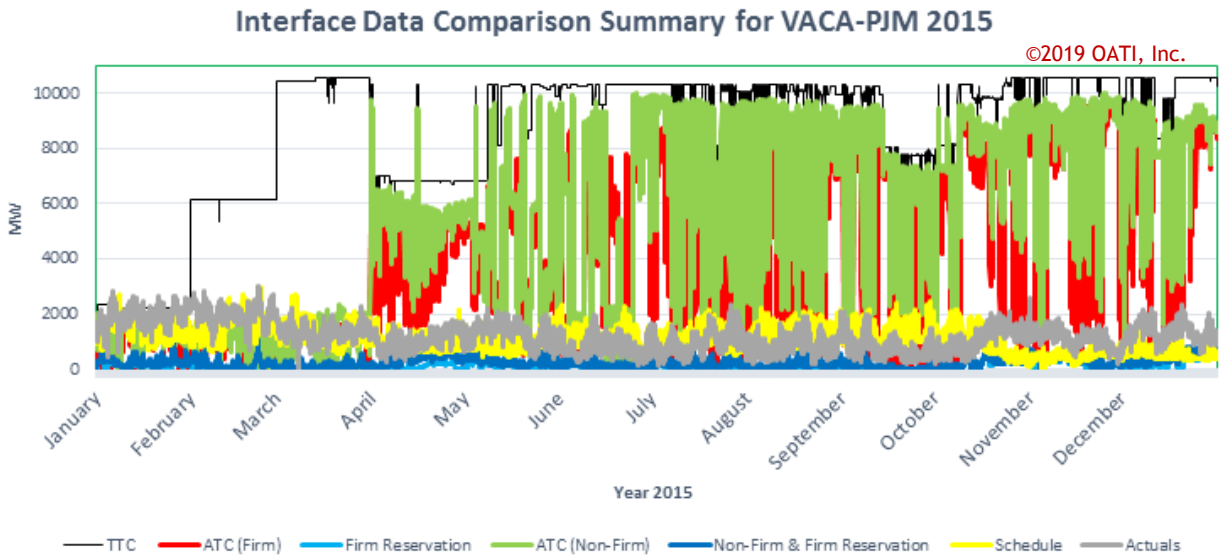


Figure 5.4-2d: Interface Comparison Summary for VACAR > PJM

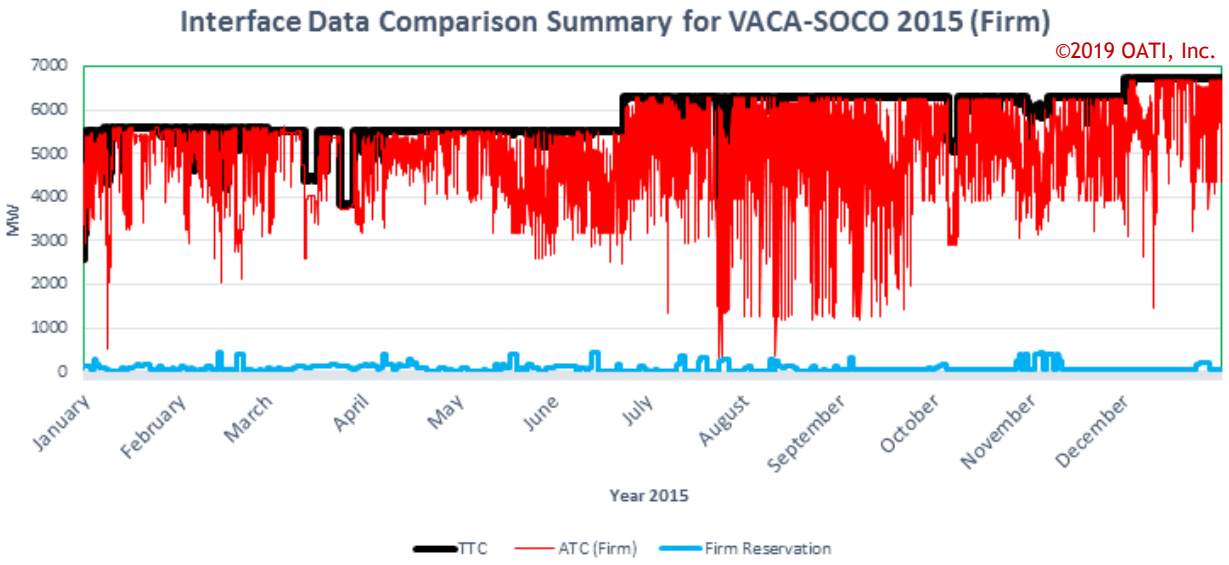


Figure 5.4-2e: Interface Firm OASIS Comparison Summary for VACAR > SOCO

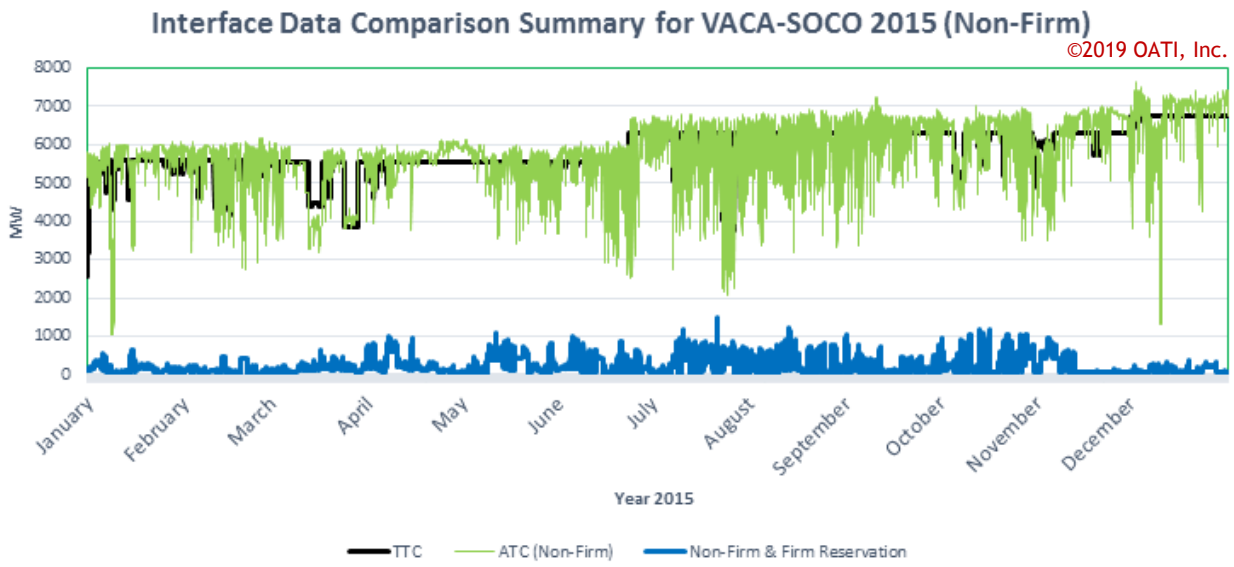


Figure 5.4-2f: Interface Non- Firm OASIS Comparison Summary for VACAR > SOCO

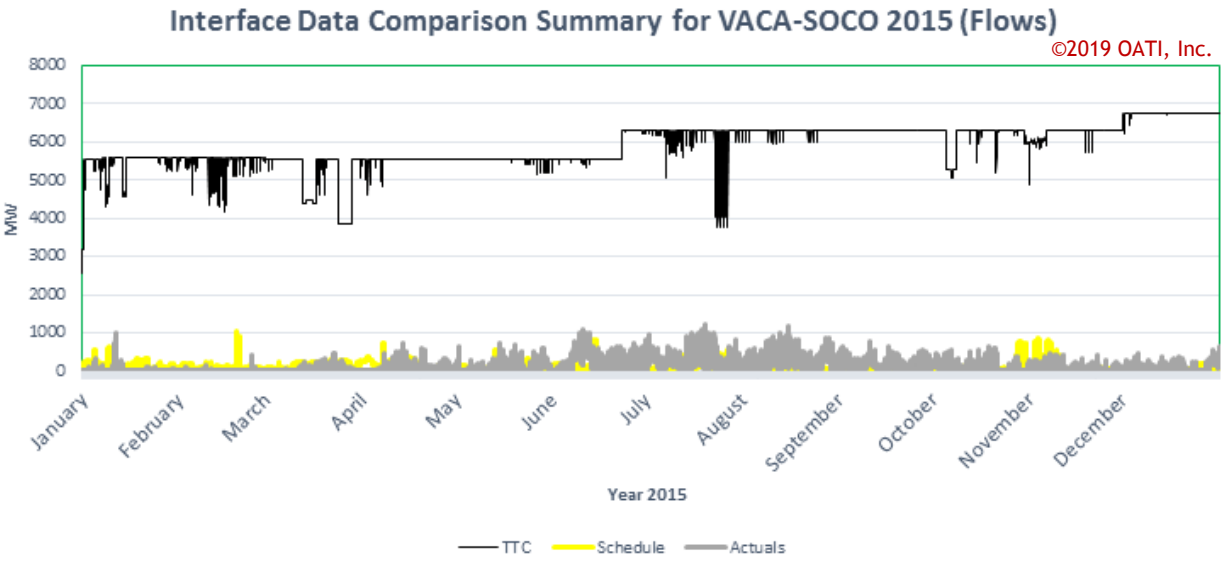


Figure 5.4-2g: Interface Flow Comparison Summary for VACAR > SOCO

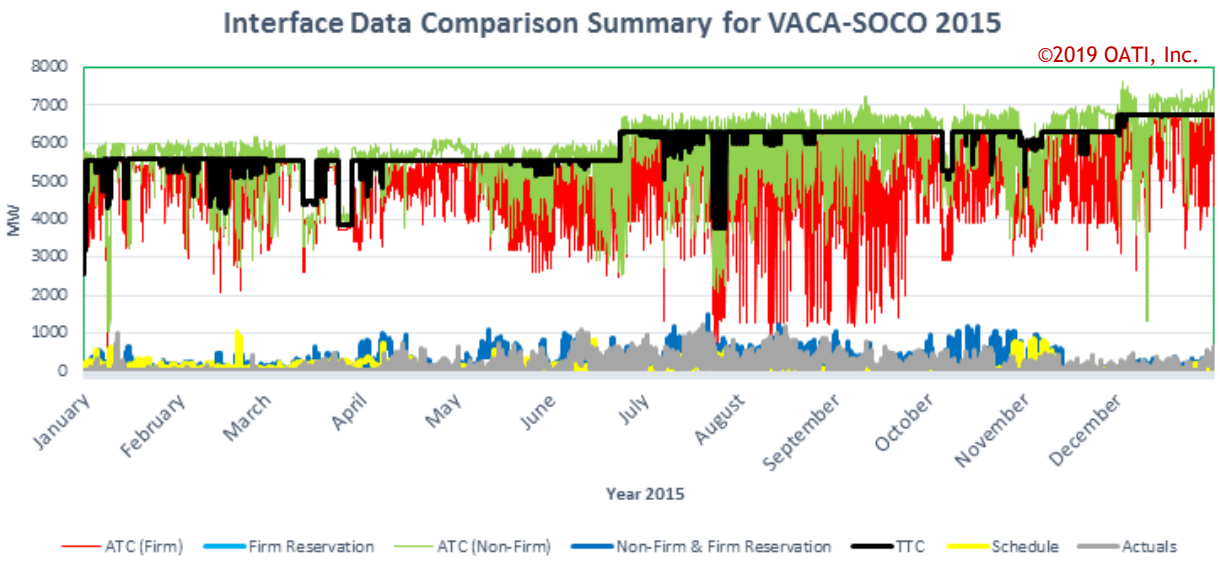


Figure 5.4-2h: Interface Comparison Summary for VACAR > SOCO

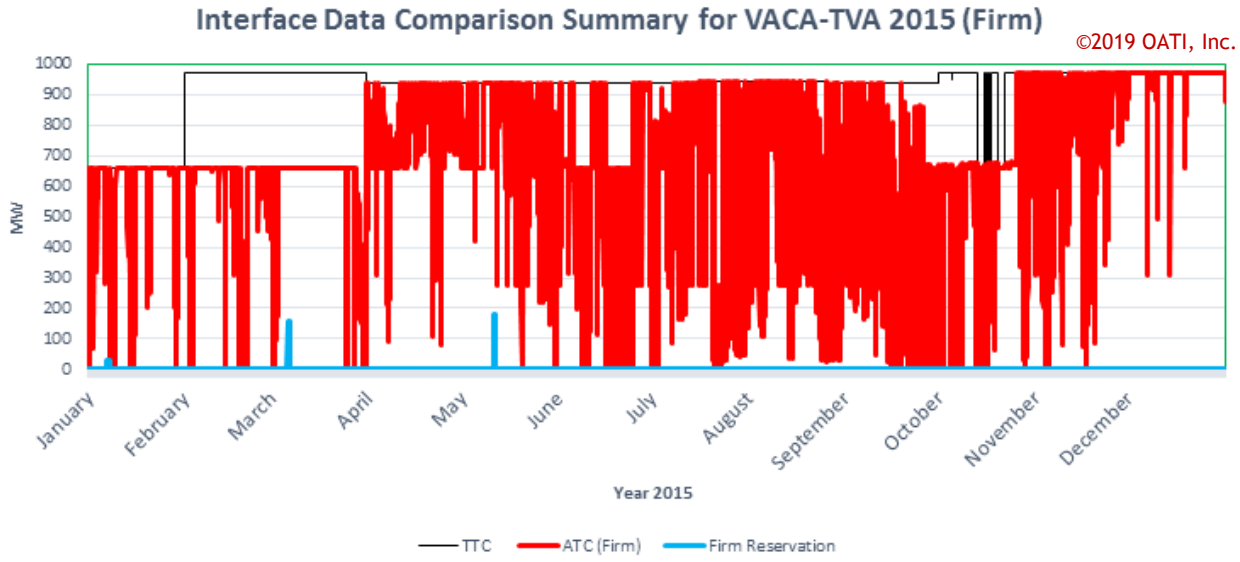


Figure 5.4-2i: Interface Firm OASIS Comparison Summary for VACAR > TVA

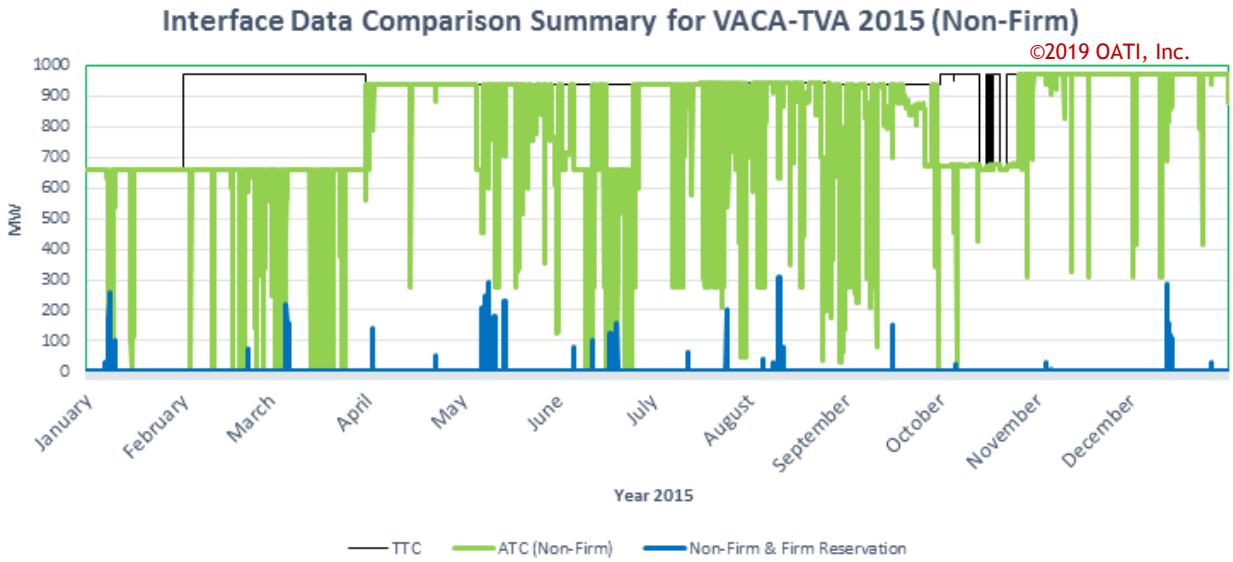


Figure 5.4-2j: Interface Non- Firm OASIS Comparison Summary for VACAR > TVA

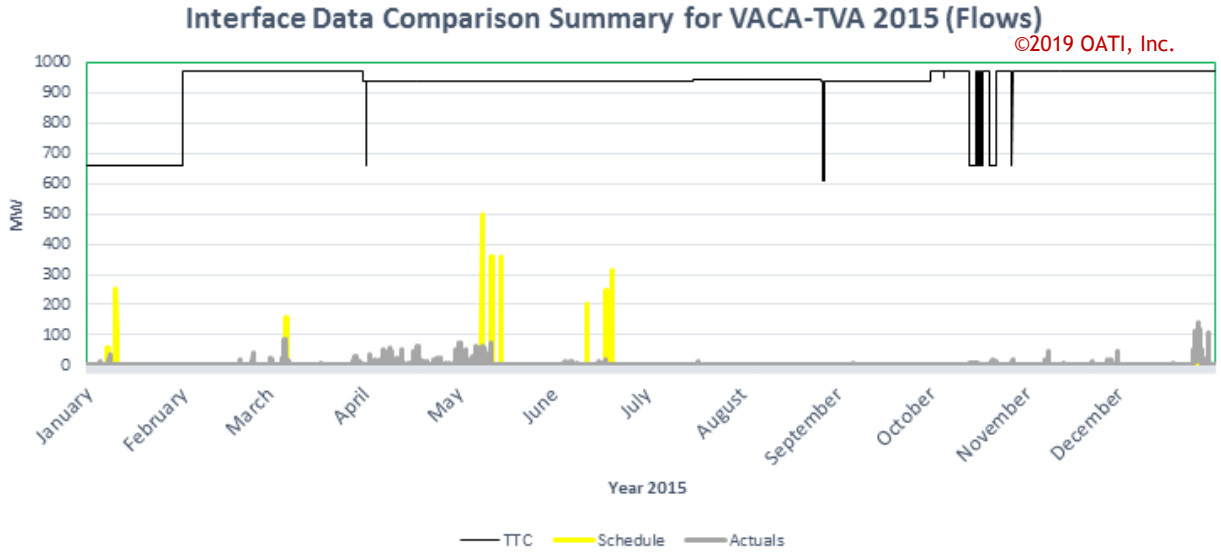


Figure 5.4-2k: Interface Flow Comparison Summary for VACAR > TVA

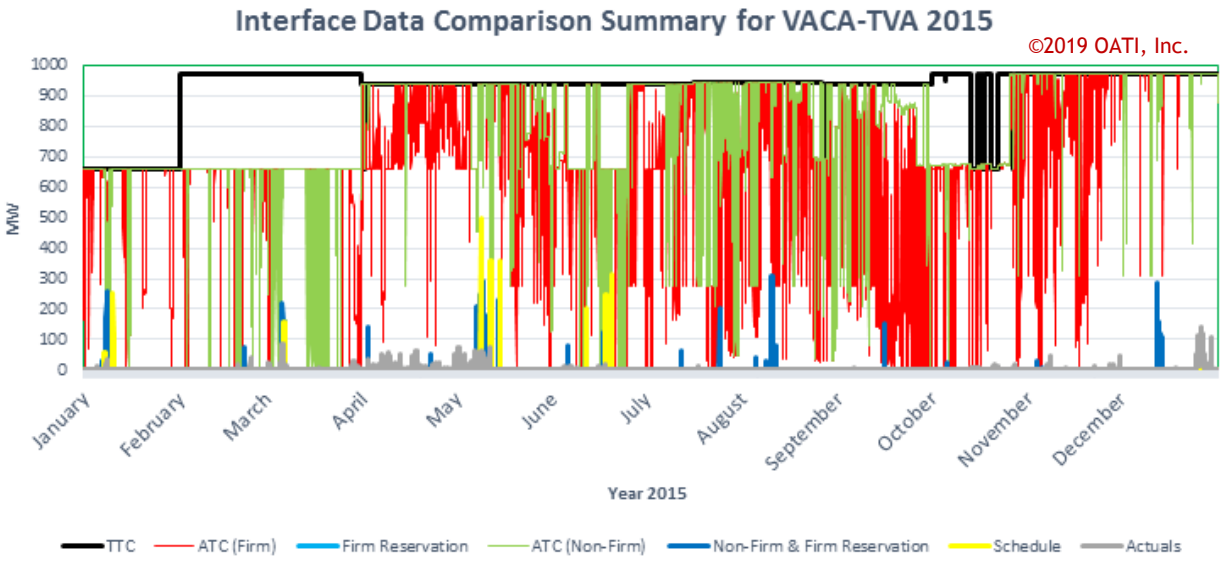


Figure 5.4-2l: Interface Comparison Summary for VACAR > TVA

5.4.4 VACAR Study Metrics Summary

Both metrics for VACAR sub-region and its interfaces between VACAR and neighboring sub-regions are summarized in this section along with the study findings. Table 5.4-7a provides the interface summary related to VACAR to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between VACAR and other sub-regions. The top limiting flowgate for each interfaces due to zero ATC and TLR is also summarized in Table 5.4-7b. Also, the highlighted flowgate in Table 5.4-7b represents the most limiting flowgate that limits VACAR interfaces due to ATC or TLR.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule /Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/ Non-Firm	Yearly TLR Count: Firm/ Non-Firm
VACAR > PJM	218/3256 (858/1238)	10/52 (452/1491)	4.38/1.57 (34.48/10.74)	0/0	0/0	208/74	294/556	85/329	0	0/181	0/22476	**0/350**
PJM > VACAR	1/136 (3301/1304)	0/0 (N/A)	0/0 (N/A)	0/0	0/0	**576/54**	0/0	0/0	0	**0/245**	0/29804	0/23
VACAR > SOCO	263/3752 (760/1129)	10/8 (169/1)	3.66/0.21 (18.25/0.14)	0/0	0/0	0/0	0/19	0/15	0	0/0	0/0	0/0
SOCO > VACAR	**3121/175 (13900/20)**	**79/1 (2071/159)**	2.46/0.56 (12.97/88.60)	97/0	**40/0**	9/6	0/0	0/0	0	0/161	0/4939	0/261
VACAR > TVA	3/66 (8/22)	0/2 (0/0.082)	0/2.94 (0/0.36)	0/0	0/0	40/171	0/0	0/0	0	0/0.43	0/33	0/1
TVA > VACAR	55/14 (738/17)	59/8 (899/5378)	**51.75/36.36 (54.90/99.67)**	**222/24**	24/0	8568/170	**2451/0**	**838/0**	**447**	0/7	0/1203	0/13

Table 5.4-7a: VACAR Interface Summary

Top Limiting Flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
VACAR > PJM	None	0	**Person-Halifax 230 kV line l/o Wake-Carson 500 kV**	**226**
VACAR > SOCO	None	0	None	0
VACAR > TVA	None	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	1

Table 5.4-7b: VACAR TLR Top Flowgates

Based on the above summary results the following observations are noted.

1. The TVA-VACAR interface is one of the most limiting interfaces in VACAR based on percentage refusal TSR count. PJM-VACAR is the most limiting interface based on TLR duration, MWh, and Zero ATC count.
2. The SOCO-VACAR is the most reserved interface based on confirmed TSR count and reservation GWh.
3. The TVA-VACAR interface is the most loaded interface during RT operation in VACAR based on U90 count (schedule). Schedules may not always represent the actual because of the RT configuration of the systems; in addition, Generation-to-Load (GTL) schedules may not be reported.
4. No firm TLRs were called on interfaces to or from VACAR; however, non-firm TLRs were called on almost all interfaces.
5. The top limiting TLR flowgate is Person-Halifax 230 kV line l/o Wake-Carson 500 kV on VACAR-PJM.

VACAR sub-region metrics are summarized below. Table 5.4-7c provides the TLR summary for the VACAR sub-region. Table 5.4-7d provides the most limiting flowgate in the VACAR sub-region.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
VACAR	0/182	0/16608	0/351

Table 5.4-7c: - VACAR TLR Sub-Region Summary

VACAR	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	227

Table 5.4-7d: MISO Top Limiting Flowgate for TLR

No firm TLRs were called on interfaces in the VACAR sub-region; however, non-firm TLRs were called, and the Person-Halifax 230 kV line l/o Wake-Carson 500 kV flowgate had most the TLRs called upon it.

5.5 SPP

5.5.1 Sub-Region Metrics

5.5.1.1 Market Metric Based on Binding Count and RT Congestion Cost

SPP provided the hourly data for binding constraints including binding constraint name, flowgate information, and the associated congestion cost for the associated year.

This study developed market metrics for SPP and identified the five most limiting flowgates based on the congestion cost. To calculate the cost associated with these constraints, (RT_CONG) was used. The flowgates considered were only those owned by the sub-region being studied.

For each hour, binding constraints with the same monitored elements were grouped and congestion costs summed. Only binding constraints owned by SPP were included for the SPP sub-regional metric calculation. The absolute value of the congestion cost was used if congestion cost was negative. All unique constraints (based on monitored element) for the year were listed out and their corresponding yearly counts were calculated.

The respective yearly cost for the constraint elements was calculated by adding up all the costs encountered for the year. Each constraint was assigned a total yearly congestion cost.

The results from the market metrics for the SPP sub-region are provided in Tables 5.5-1a and 5.5-1b.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours
1	WDWFPLTATNOW	3154	14.10%
2	OSGCANBUSDEA	3139	14.04%
3	TEMP56_21085	2635	11.78%
4	TMP169_21252	754	03.37%
5	TMP144_21263	739	03.30%

Table 5.5-1a: Five Most Limiting Binding Constraint in SPP Sub-region (By Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)	% Congestion Cost
1	WDWFPLTATNOW	50.5	14.87%
2	OSGCANBUSDEA	41.4	12.18%
3	IATSTRSTJHAW	13.8	04.07%
4	TEMP56_21085	13.6	04.01%
5	TMP109_20517	11.6	03.41%

Table 5.5-1b: Five Most Limiting Binding Constraints in the SPP Sub-Region (by Cost)

5.5.1.2 Market Flow Metric based on Binding Count and Market Flow Settlement Cost

Market flow metrics were developed that identify the five most limiting flowgates by their binding count and congestion cost.

MTM settlement costs (MTM-credit/payment) were used to calculate market flow cost associated with these constraints. The absolute value of the MTM cost was used if the MTM cost was negative. Binding constraints with same monitored elements were grouped and congestion costs summed for each hour. For each sub-regional metric calculation, only binding constraints owned by that sub-region were included.

All unique constraints (based on monitored elements) for the year were listed out and their corresponding yearly counts were calculated. Each constraint was assigned a total yearly congestion cost.

The results from the Market flow metrics for the SPP sub-region are provided in Tables 5.5-2a and 5.5-2b.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours
1	TMP144_21263	514	26.09%
2	TEMP49_21150	242	12.28%
3	IATSTRSTJHAW	189	09.59%
4	TEMP82_20951	175	08.88%
5	TMP109_20517	136	06.90%

Table 5.5-2a: Five Most Limiting SPP Binding Constraints to the Market Flow Impacts (by Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)	% Congestion Cost
1	CBLS56ROLMAD	3.2	29.75%
2	TMP122_20835	1.1	10.28%
3	TEMP49_21150	1.0	09.68%
4	SUBTEKFTCRAU	1.0	09.50%
5	IATSTRSTJHAW	0.7	07.14%

Table 5.5-2b: Five Most Limiting SPP Binding Constraints to the Market Flow Impacts (by Cost)

5.5.1.3 TLR Metrics

This study also developed TLR metrics for the SPP sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

Sub-region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
SPP	0	0	0	219	6665	468

Table 5.5-3a: TLR metrics for the SPP Sub-Region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
SPP	None	0	0	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	109	1062
				TEMP05 Mandan - Dickenson 230 kV (flo) Antelope Valley - Charlie Creek 345 kV	45	35
				RedWillMingo	45	248
				Fairport - Osborn 161 flo St. Joe - Cooper 345.	42	26
				Raun345_161kV_TR2_flo_Raun_SiouxCity_345	29	1472

Table 5.5-3b: Top Five Limiting Flowgates (Count-Based) for the SPP Sub-Region

5.5.2 Interface Metrics

For SPP, OASIS data were available only for some sub-paths with MISO. Therefore, OASIS data for SPP-MISO were taken from MISO's OASIS.

5.5.2.1 Transmission Service Request Metric

This metric counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces. The results from the TSR metric for the SPP interfaces are provided in Tables 5.5-4a through 5.5-4d.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
SPP > MISO	23	51	68.91%
MISO > SPP	33	9	21.43%
SPP > NON RTO MIDWEST	*	*	*
NON RTO MIDWEST > SPP	19	4	17.4%

Table 5.5-4a: Firm Confirmed and Refused TSR Count

Interface	Non-Firm Confirmed TSR Count	Non-Firm Refused TSR Count	% Refusal
SPP > MISO	0	34	100%
MISO > SPP	984	444	31.09%
SPP > NON RTO MIDWEST	*	*	*
NON RTO MIDWEST > SPP	2212	746	25.21%

Table 5.5-4b: Non-Firm Confirmed and Refused TSR Count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
SPP > MISO	752688	1074266	58.50
MISO > SPP	19880914	252288	1.25
SPP > NON RTO MIDWEST	*	*	*
NON RTO MIDWEST > SPP	17323808	84000	0.48

Table 5.5-4c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
SPP > MISO	0	295085	100
MISO > SPP	254747	59007	18.81
SPP > NON RTO MIDWEST	*	*	*
NON RTO MIDWEST > SPP	475646	748850	61.15

Table 5.5-4d: Non-Firm Confirmed and Refused Reservation MWh

5.5.2.2 Transmission Reservation Utilization Metric

The results from the Transmission Service Utilization Metric for the SPP interfaces are provided in Tables 5.5-5a and 5.5-5b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
SPP > MISO	0	0
MISO > SPP	0	0
SPP > NON RTO MIDWEST	*	*
NON RTO MIDWEST > SPP	0	0

Table 5.5-5a: TRU75 for Firm and Non-Firm Reservations

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
SPP > MISO	0	0
MISO > SPP	0	0
SPP > NON RTO MIDWEST	*	*
NON RTO MIDWEST > SPP	0	0

Table 5.5-5b: TRU90 for Firm and Non-Firm Reservations

5.5.2.3 Zero ATC Metrics

The results from the ATC metric for SPP interfaces are provided in Table 5.5-6.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
SPP > MISO	8733	3242
MISO > SPP	8563	3061
SPP > NON RTO MIDWEST	*	*
NON RTO MIDWEST > SPP	*	*

Table 5.5-6: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.5-1a through 5.5-1d).

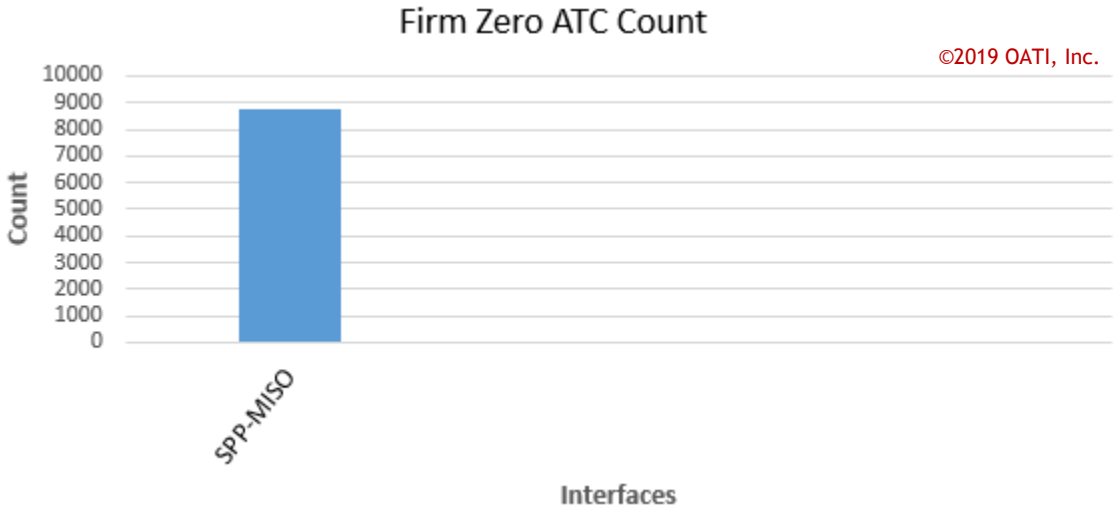


Figure 5.5-1a: Firm Zero ATC Count

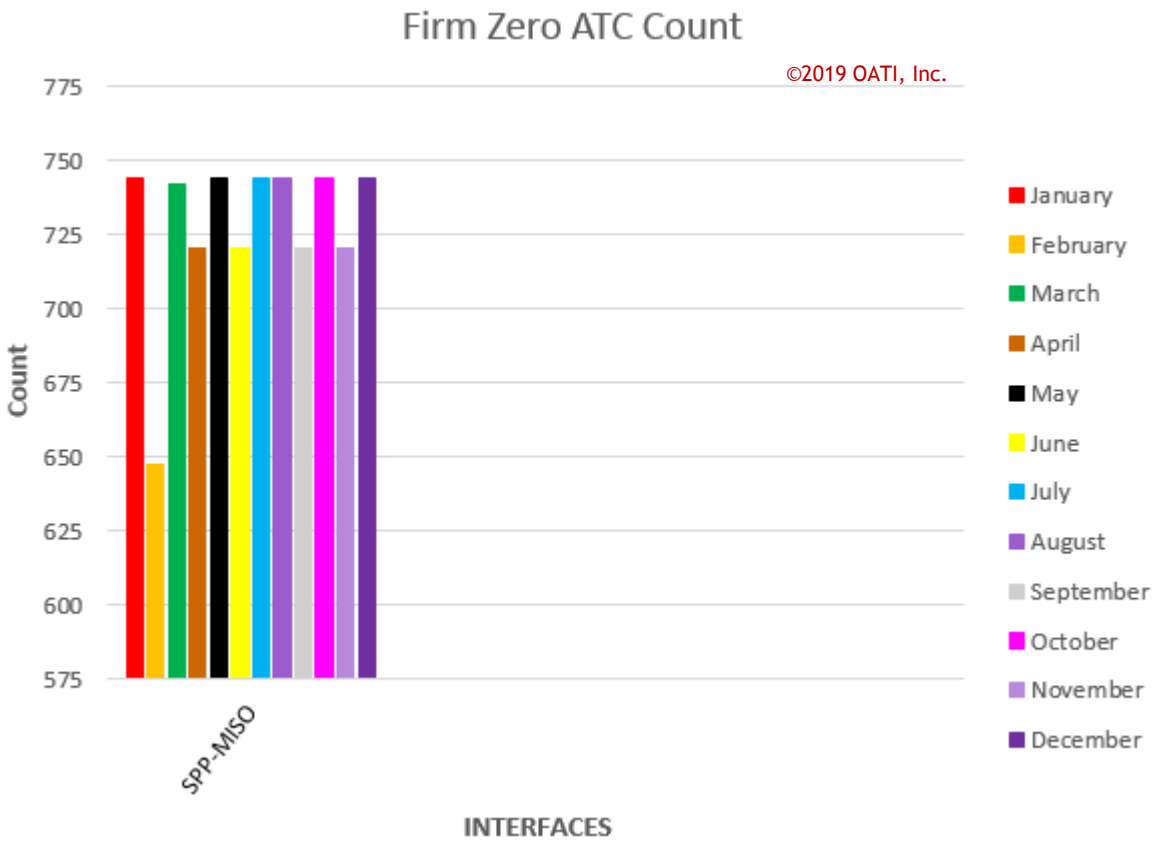


Figure 5.5-1b: Firm Zero ATC Count

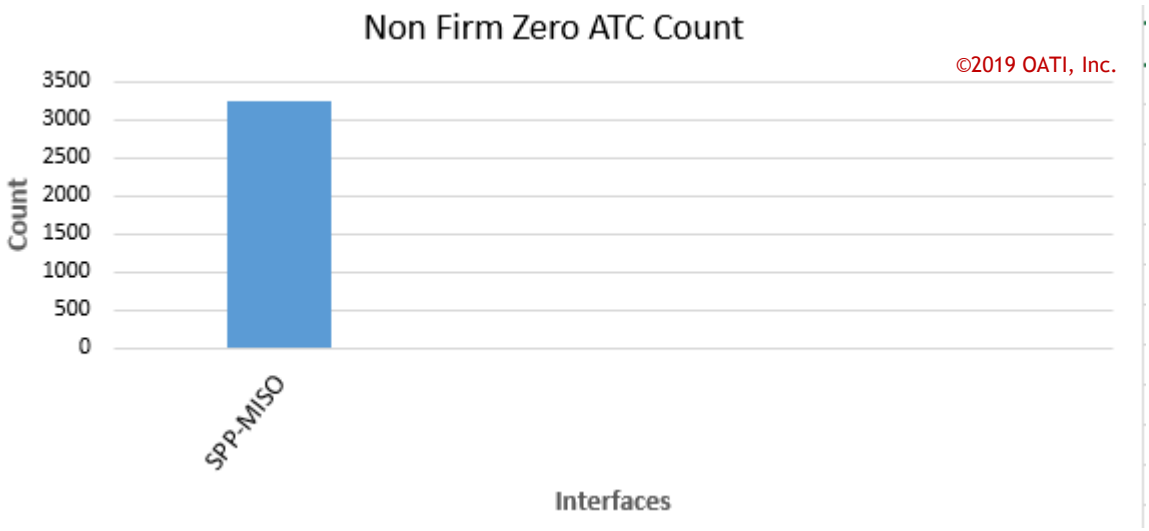


Figure 5.5-1c: Non-Firm Zero ATC Count

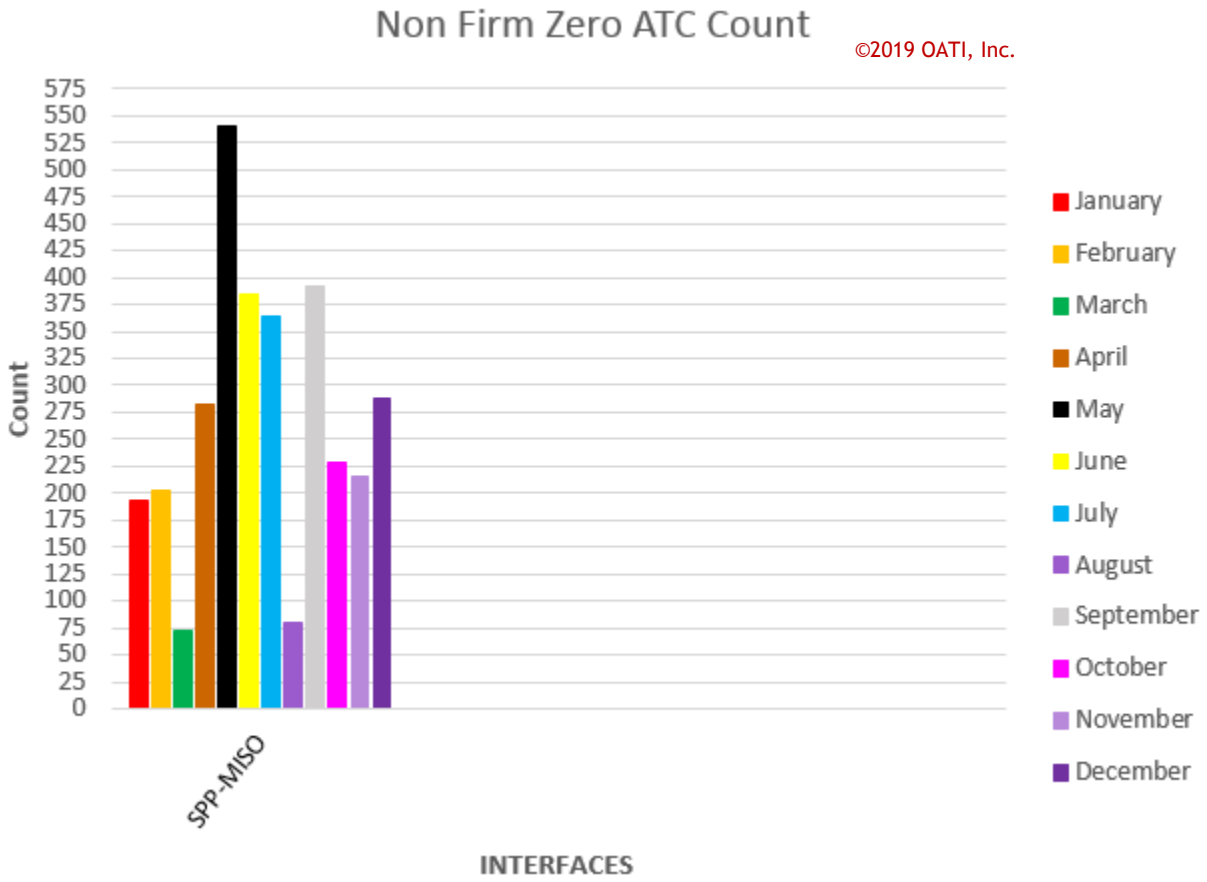


Figure 5.5-1d: Non-Firm Zero ATC Count

5.5.2.4 Schedule Utilization Metrics and Actual Flow Metrics

The results from the schedule utilization metrics and actual flow metrics for SPP interfaces are provided in Tables 5.5-7a and 5.5-7b.

Interface	U75 Schedule Count	U90 Schedule Count
SPP > MISO	0	0
MISO > SPP	0	0
SPP > NON RTO MIDWEST	*	*
NON RTO MIDWEST > SPP	0	0

Table 5.5-7a: Scheduled Flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
SPP > MISO	0	0
MISO > SPP	0	0
SPP > NON RTO MIDWEST	*	*
NON RTO MIDWEST > SPP	0	0

Table 5.5-7b: Actual Flow Utilization Metric

Metrics for interfaces based on a schedule count above the TTC were also developed. The results for the metrics are provided in Table 5.5-7c.

Interface	Schedule Count above TTC
SPP > MISO	0
MISO > SPP	0
SPP > NON RTO MIDWEST	*
NON RTO MIDWEST > SPP	0

Table 5.5-7c: Schedule Count above TTC

5.5.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR Metric for the interfaces are provided in Tables 5.5-8a and 5.5-8b.

Interface	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
SPP > MISO	0	0	0	86	1839	178
MISO > SPP	0	0	0	0	0	0
SPP > NON RTO MIDWEST	*	*	*	89	177	43
NON RTO MIDWEST > SPP	*	*	*	64	2309	32

Table 5.5-8a: TLR Metrics for SPP Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
SPP > MISO	None	0	0	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	51	1024
				Fairport - Osborn 161 flo St. Joe - Cooper 345.	42	25
				TEMP40: Buckner - Spearville 345kV ftlo Potter 345/230 xfmr	22	107
				Fairport - Osborn 161kV flo Eastown Iatan 345kV	14	31
				TMP167_20869 BullShoals-Buford FTLO W_Memphis-Keo 500kV	9	175
SPP > NON RTO MIDWEST	*	*	*	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	58	38
				CatXfrCatXfr	16	13
				Fairport - Osborn 161kV (flo) St. Joe - Hawthorn 345kV	7	47
				Palmyra 345/161 Xfm (flo) Montgomery-Spencer 345	5	19
				TMP167_20869 BullShoals-Buford FTLO W_Memphis-Keo 500kV	3	59

Table 5.5-8b: Top Five Limiting Flowgates (Count-Based) for SPP Interfaces

5.5.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all the SPP interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm

ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all parameters.

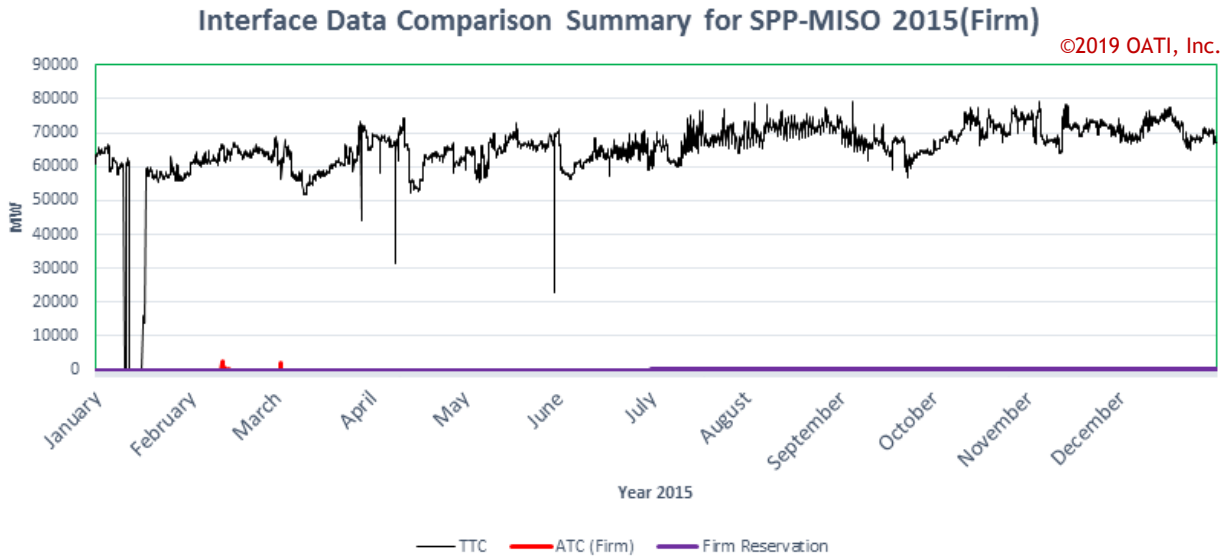


Figure 5.5-2a: Interface Firm OASIS Comparison Summary for SPP > MISO

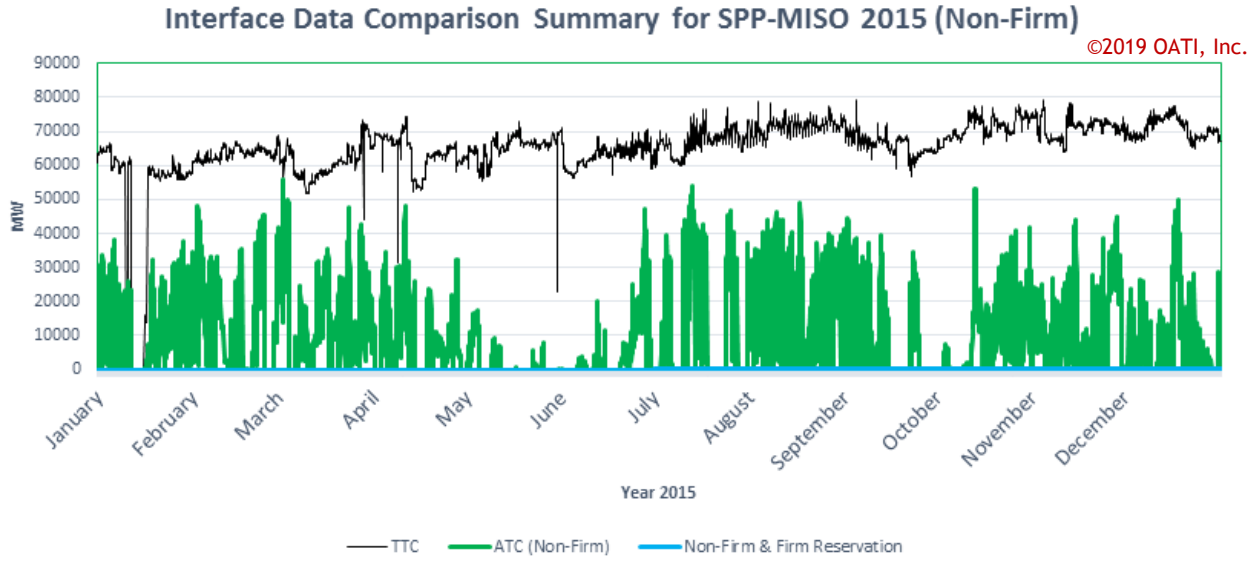


Figure 5.5-2b: Interface Non-Firm OASIS Comparison Summary for SPP > MISO

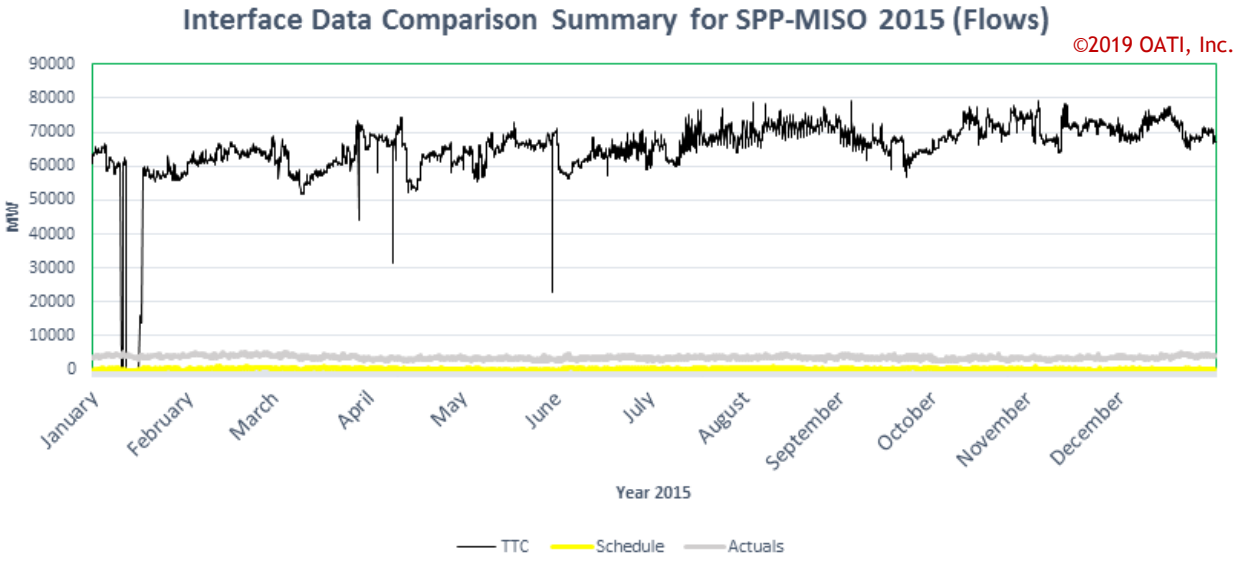


Figure 5.5-2c: Interface Flow Comparison Summary for SPP > MISO

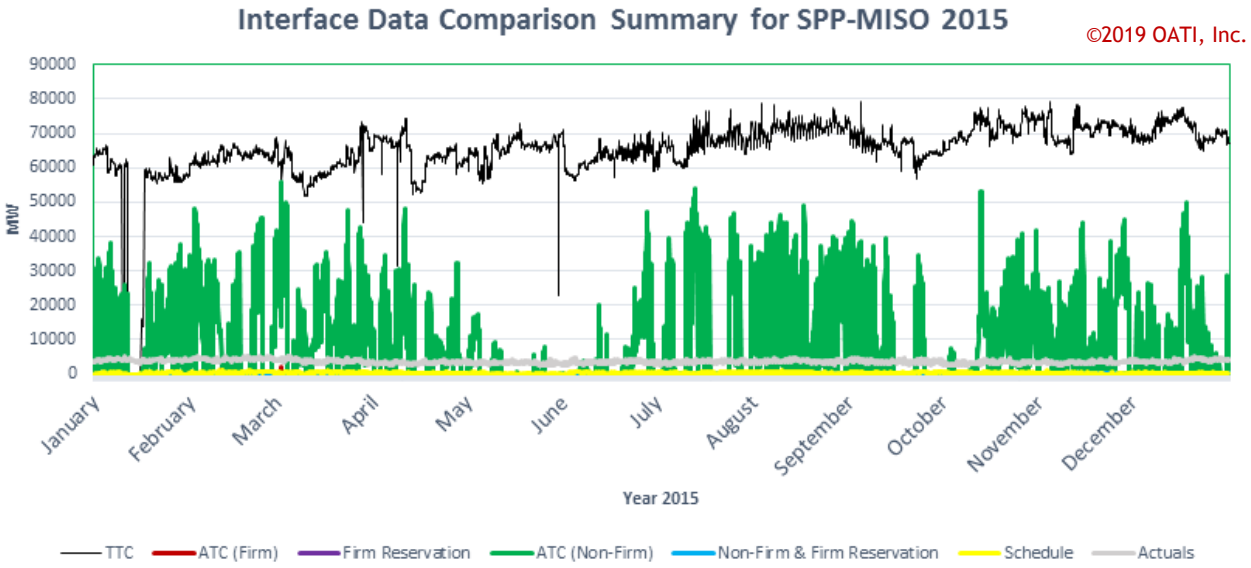


Figure 5.5-2d: Interface Comparison Summary for SPP > MISO

5.5.4 SPP Study Metrics Summary

Both metrics for the SPP sub-region and its interfaces between SPP and neighboring sub-regions are summarized in this section along with the study findings. Table 5.5-9a provides the interface summary related to SPP to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below represent the highest metric values among all of the interfaces between SPP and other sub-regions. The top limiting flowgate for each interface due to TLR is summarized in Table 5.5-9b.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule/Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
SPP > MISO	23/0 (752/0)	**51/34 (1074/295)**	**68.91/100 (58.5/100)**	0/0	0/0	**8733/3242**	0/0	0/0	0	**0/86**	**0/1839**	**0/178**
MISO > SPP	**33/984 (19880/254)**	9/444 (252/59)	21.43/31.09 (1.25/18.81)	0/0	0/0	8563/3061	0/0	0/0	0	0/0	0/0	0/0
SPP > NON RTO MIDWEST	*	*	*	*	*	*	*	*	*	0/89	0/177	0/43
NON RTO MIDWEST > SPP	19/2212 (17323/475)	4/746 (84/748)	17.4/25.2 (0.48/61.15)	0/0	0/0	*	0/0	0/0	0/0	0/64	0/2309	0/32

Table 5.5-9a: SPP Interface Summary

Top Limiting Flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
SPP > MISO	None	0	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	51
SPP > NON RTO MIDWEST	None	0	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	58

Table 5.5-9b: SPP TLR Top Flowgates

Based on the above summary results the following observations are noted.

1. The SPP-MISO interface is the most limiting interface in the SPP-based sub-region based on the refused TSR count, percentage Refusal TSR count and, TLR duration, TLR MWh, and TLR count and it is also most limiting based on Zero ATC.
2. The MISO-SPP is the most reserved interface based on confirmed TSR count and reservation GWh.
3. No firm TLRs were called on interfaces to or from SPP; however, non-firm TLRs were called on almost all interface. The top limiting TLR flowgate was TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV. The name suggests it might be a temporary flowgate.

SPP sub-region metrics are summarized below. Table 5.5-9c provides the TLR summary for the SPP sub-region. Table 5.5-9d provides the most limiting flowgate in the SPP sub-region due to TLR. Table 5.5-9e provide the most limiting binding constraint that limits the SPP sub-region during the RT market. Table 5.5-9f provide the most limiting binding constraint that limits the SPP sub-region during the RT market due to market flow.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
SPP	0/219	0/6	0/468

Table 5.5-9c: - SPP TLR Sub-Region Summary

SPP	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top Limiting Flowgate	None	0	TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV	109

Table 5.5-9d: SPP Top Limiting Flowgate for TLR

SPP	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour Count	Binding Constraints Name	Congestion Cost
Top Binding Constraint	WDWFPLTATNOW	3154	WDWFPLTATNOW	$50.5 M

Table 5.5-9e: Most Limiting Binding Constraint in SPP Sub-region

SPP	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour Count	Binding Constraints Name	Congestion Cost
Top Binding Constraint	TMP144_21263	514	CBLS56ROLMAD	$3.2

Table 5.5-9f: Most Limiting SPP Binding Constraints Due to the Market Flow Impacts

1. No firm TLRs were called on interfaces in the SPP sub-region; however, non-firm TLRs were called and the TEMP 109: Swissvale - West Gardner 345kV ftlo 87th St - Craig 345kV flowgate had the most TLRs called upon it.
2. In the SPP market, the most limiting binding constraint due to congestion cost was WDWFPLTATNOW, and the most limiting SPP owned binding constraint due to market flow was CBLS56ROLMAD.
3. In addition, a separate comparison was performed which is included in Appendix D based on the DOE's *Annual U.S. Transmission Data Review* that published a list of constraints observed in the SPP sub-region in 2014. The three constraints (OSGCANBUSDEA, WDWFPLTATNOW, and IATSTRSTJHAW) show up both this study and in the *Annual U.S. Transmission Data Review*.

5.6 TVA

5.6.1 Sub-Region Metrics

5.6.1.1 TLR Metrics

This study also developed TLR metrics for the TVA sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

TVA	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
	0	0	0	215	17583	436

Table 5.6-1a: TLR Metrics for the TVA sub-region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
TVA	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	111	941
				Person-Halifax 230 kV line l/o Wake-Carson 500 kV	82	3525
				Paradise-Big River Tap FLO Wilson1	78	3379
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	72	2770
				Person-Halifax 230 kV line	30	821

Table 5.6-1b: Top Five Limiting Flowgates (Count Based) for TVA Sub-region

5.6.2 Interface Metrics

5.6.2.1 Transmission Service Request Metric

The results from the TSR metrics for the TVA interfaces are provided in Table 5.6-2a. These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
TVA > MISO	6	30	83.33%
MISO > TVA	17	193	91.90%
TVA > SOCO	93	137	59.56%
SOCO > TVA	311	30	08.79%
TVA > VACAR	55	59	51.75%
VACAR > TVA	3	0	0
TVA > PJM	210	1660	88.77%
PJM > TVA	29	13	30.90%
TVA > Non RTO Midwest	3	2	40.00%
Non RTO Midwest > TVA	19	17	47.2%

Table 5.6-2a: Firm Confirmed and Refused TSR count

Interface	Non-Firm Confirmed TSR Count	Non-Firm Refused TSR Count	% Refusal
TVA > MISO	29	22	13.13%
MISO > TVA	149	155	50.99%
TVA > SOCO	109	94	46.31%
SOCO > TVA	156	4	02.50%
TVA > VACAR	14	8	36.36%
VACAR > TVA	66	2	02.94%
TVA > PJM	1038	733	41.39%
PJM > TVA	317	0	0
TVA > Non RTO Midwest	0	8	0
Non RTO Midwest > TVA	96	20	17.24%

Table 5.6-2b: Non-Firm Confirmed and Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
TVA > MISO	5428530	1870815	25.63
MISO > TVA	5454096	2641704	32.63
TVA > SOCO	2504032	545876	17.90
SOCO > TVA	603806	95616	13.67
TVA > VACAR	738868	899370	54.90
VACAR > TVA	8880	0	0.00
TVA > PJM	3543819	145767380	97.63
PJM > TVA	9453936	NA	NA
TVA > Non RTO Midwest	821926	3384	0.41
Non RTO Midwest > TVA	7464	0	0.00

Table 5.6-2c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
TVA > MISO	3766	45603	92.37
MISO > TVA	39182	424820	91.56
TVA > SOCO	47584	45503	48.88
SOCO > TVA	306405	93	0.03
TVA > VACAR	17906	5378363	99.67

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
VACAR > TVA	22875	82	0.36
TVA > PJM	648031	1320049	67.07
PJM > TVA	195697	NA	NA
TVA > Non RTO Midwest	0	4220	100.00
Non RTO Midwest > TVA	21108	4004	15.94

Table 5.6-2d: Non-Firm Confirmed and Refused Reservation MWh

5.6.2.2 Transmission Reservation Utilization Metric

The results from the Transmission Service Utilization metrics for the TVA interfaces are provided in Table 5.6-3a.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
TVA > MISO	0	0
MISO > TVA	0	0
TVA > SOCO	0	0
SOCO > TVA	120	0
TVA > VACAR	222	24
VACAR > TVA	0	0
TVA > PJM	0	0
PJM > TVA	0	0
TVA > Non RTO Midwest	0	0
Non RTO Midwest > TVA	0	0

Table 5.6-3a: TRU75 for Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
TVA > MISO	0	0
MISO > TVA	0	0
TVA > SOCO	0	0
SOCO > TVA	70	0
TVA > VACAR	24	0
VACAR > TVA	0	0
TVA > PJM	0	0

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
PJM > TVA	0	0
TVA > Non RTO Midwest	0	0
Non RTO Midwest > TVA	0	0

Table 5.6-3b: TRU90 for Reservation

5.6.2.3 Zero ATC Metrics

The results from ATC Metric for TVA interfaces are provided in Table 5.6-4.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
TVA > MISO	8520	6
MISO > TVA	8493	4511
TVA > SOCO	7967	37
SOCO > TVA	144	22
TVA > VACAR	8568	170
VACAR > TVA	400	171
TVA > PJM	8687	228
PJM > TVA	3384	270
TVA > Non RTO Midwest	8760	946
Non RTO Midwest > TVA	1280	130

Table 5.6-4: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.6-1a through 5.6-1d).

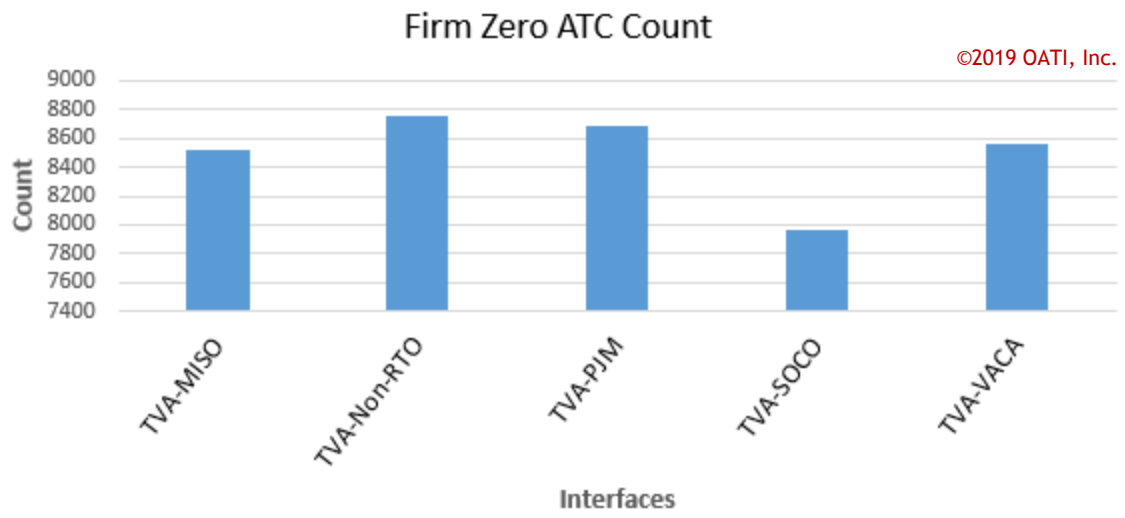


Figure 5.6-1a: Firm Zero ATC Count

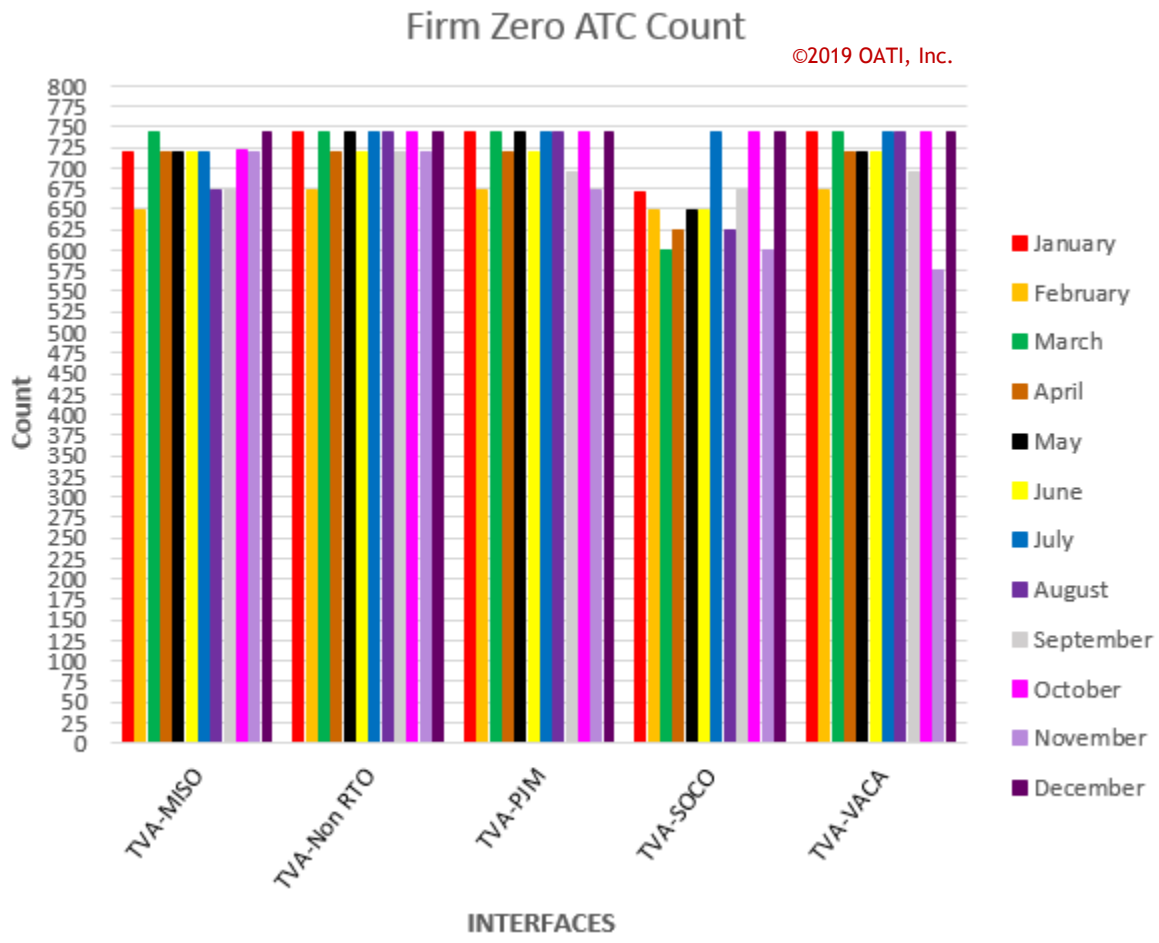


Figure 5.6-1b: Firm Zero ATC Count

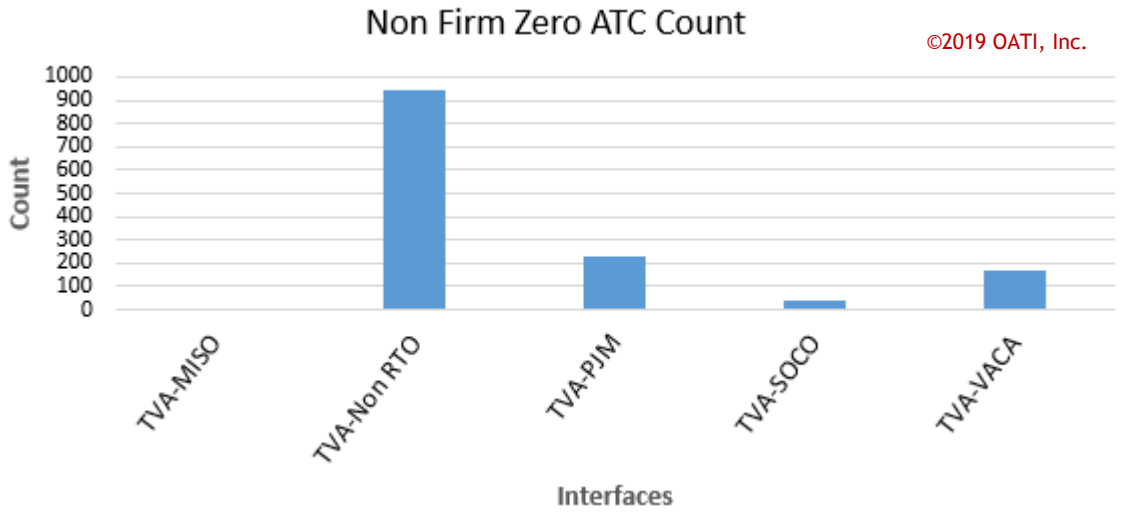


Figure 5.6-1c: Non-Firm Zero ATC Count

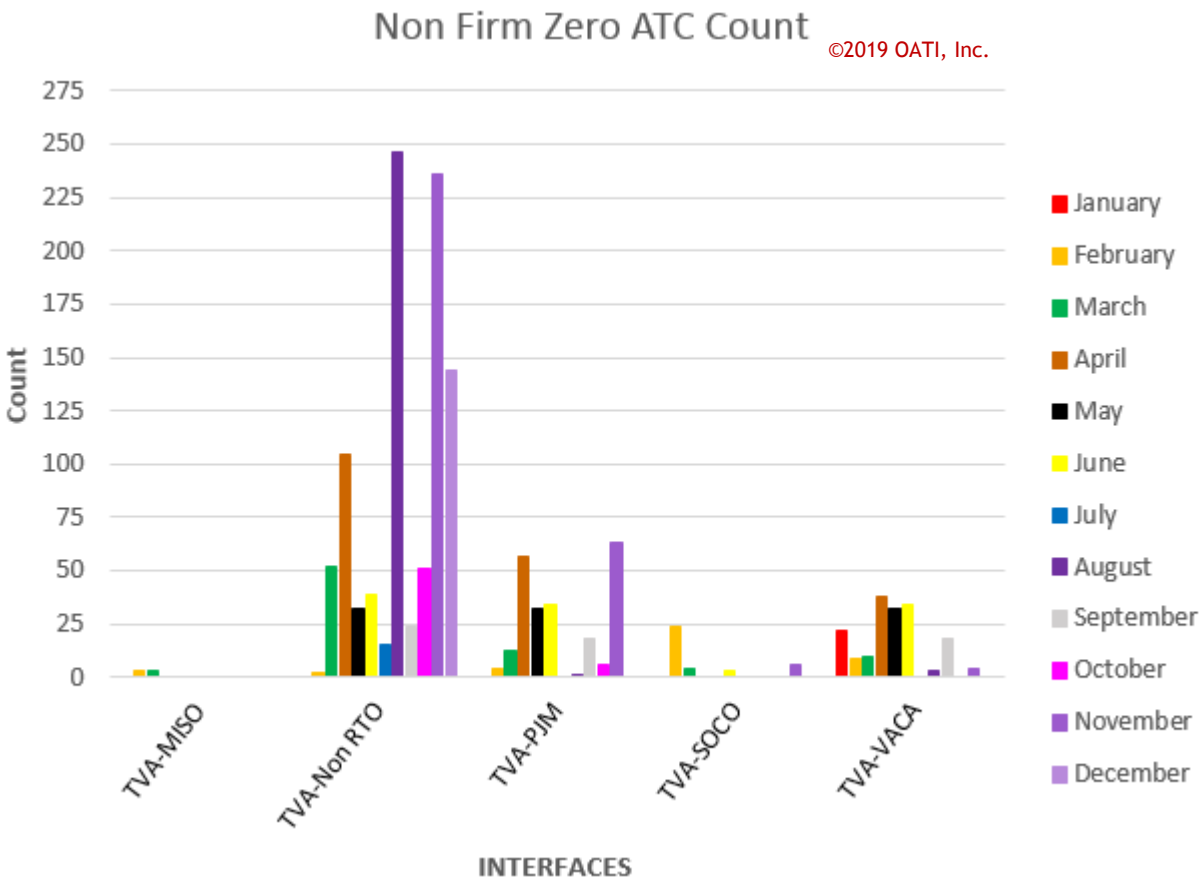


Figure 5.6-1d: Non-Firm Zero ATC Count

5.6.2.4 Schedule Utilization Metrics and Actual flow Metrics

Schedule utilization metrics and actual flow metrics were calculated for the interfaces. The utilization metric U75 provides a total yearly count for an interface where the hourly scheduled flow exceeds 75 percent of the TTC. The utilization metric U90 provides total yearly count for an interface where the hourly schedule/flow exceeds 90 percent of the TTC. As Actual flow was not provided by TVA, corresponding flow provided by other direction was used.

The results from the schedule utilization metrics and actual flow metrics for the interfaces are provided in Table 5.6-5a and Table 5.6-5b.

Interface	U75 Schedule Count	U90 Schedule Count
TVA > MISO	97	21
MISO > TVA	0	0
TVA > SOCO	0	0
SOCO > TVA	69	57
TVA > VACAR	2451	838
VACAR > TVA	0	0
TVA > PJM	869	60
PJM > TVA	0	0
TVA > Non RTO Midwest	0	0
Non RTO Midwest > TVA	0	0

Table 5.6-5a: Scheduled flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
TVA > MISO	174	49
MISO > TVA	5	1
TVA > SOCO	182	58
SOCO > TVA	20	16
TVA > VACAR	0	0
VACAR > TVA	0	0
TVA > PJM	0	0
PJM > TVA	0	0

Interface	U75 Actual Count	U90 Actual Count
TVA > Non RTO Midwest	0	0
Non RTO Midwest > TVA	0	0

Table 5.6-5b: Actual flow Utilization Metric

Metrics for interfaces based on a schedule count above the TTC was also developed. The results for the metrics are provided in Table 5.6-5c.

Interface	Schedule Count above TTC
TVA > MISO	11
MISO > TVA	0
TVA > SOCO	0
SOCO > TVA	44
TVA > VACAR	447
VACAR > TVA	0
TVA > PJM	0
PJM > TVA	0
TVA > Non RTO Midwest	0
Non RTO Midwest > TVA	0

Table 5.6-5c: Schedule Count above TTC

5.6.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metrics for the interfaces are provided in Table 5.6-6a and Table 5.6-6b.

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
TVA > MISO	0	0	0	30	127	59
MISO > TVA	0	0	0	41	3523	79

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
TVA > SOCO	0	0	0	6	818	16
SOCO > TVA	0	0	0	4	12	8
TVA > VACAR	0	0	0	7	1203	13
VACAR > TVA	0	0	0	0.43	33	1
TVA > PJM	0	0	0	162	12073	328
PJM > TVA	0	0	0	0	0	0
TVA > Non RTO Midwest	0	0	0	10	174	20
Non RTO Midwest > TVA	0	0	0	29	171	14

Table 5.6-6a: TLR Metrics for Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
TVA > MISO	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	41	103
				Paradise-Big River Tap FLO Wilson1	12	12
				Paradise_BRTap_161kV_flo_Wilson _Roane_500kV	6	13
TVA > SOCO	None	0	0	Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	16	818
TVA > VACAR	None	0	0	Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	9	1133
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	2	28
				Paradise-Big River Tap FLO Wilson1	2	41
TVA > PJM	None	0	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	82	3525
				Paradise-Big River Tap FLO Wilson1	64	3325
				Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	54	793
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	47	819
				Person-Halifax 230 kV line	30	821
TVA > Non RTO Midwest	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	14	17
				Livingston-Crittenden 161 kV (flo) Livingston-North Princeton 161 kV	4	3317
				Paradise Northeast Corridor	2	26

Table 5.6-6b: Top Five Limiting Flowgates (Count-Based) for TVA Interfaces

5.6.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all study interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all parameters.

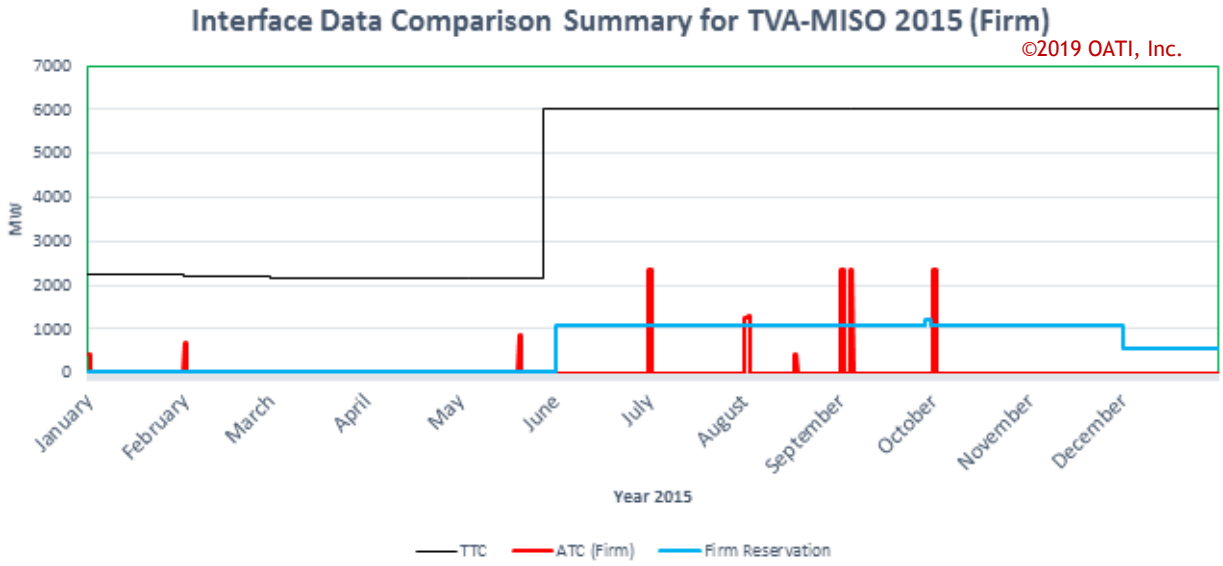


Figure 5.6-2a: Interface Firm OASIS Comparison Summary for TVA > MISO

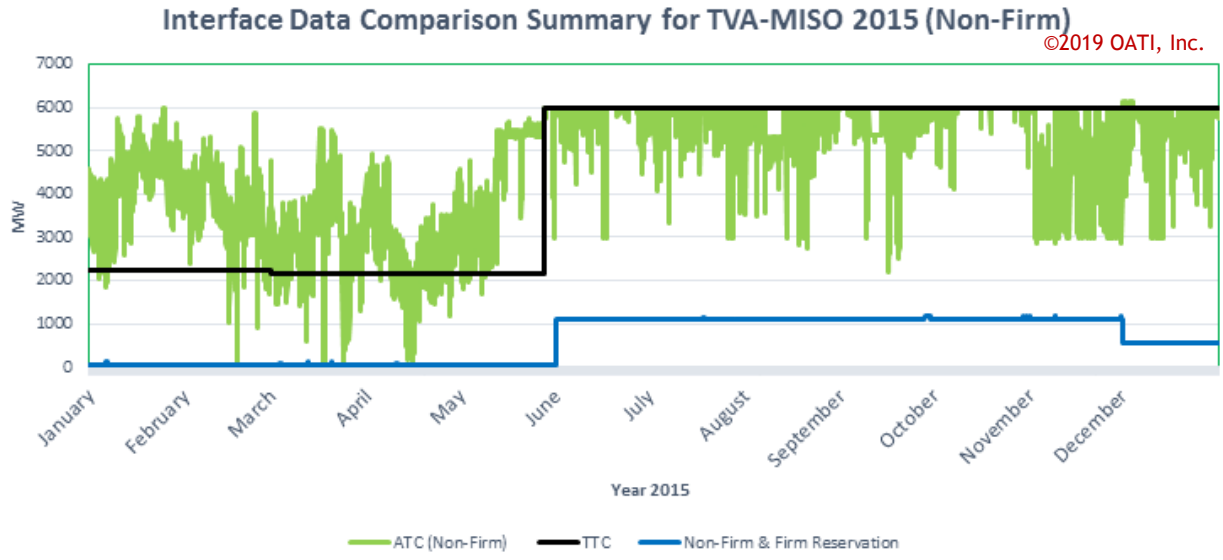


Figure 5.6-2b: Interface Non-Firm OASIS Comparison Summary for TVA > MISO

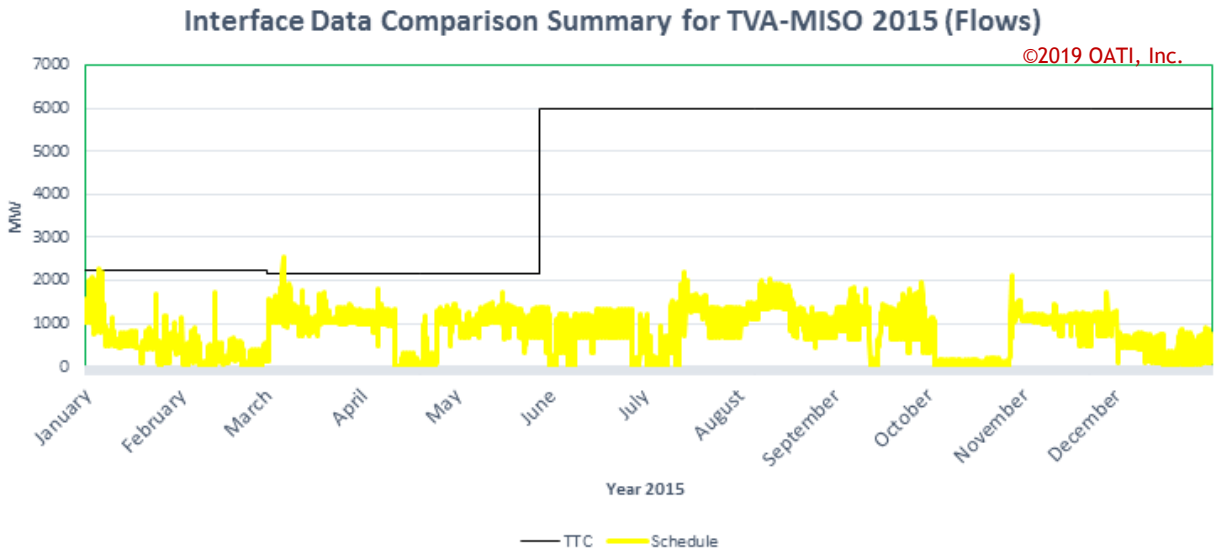


Figure 5.6-2c: Interface Flow Comparison Summary for TVA > MISO

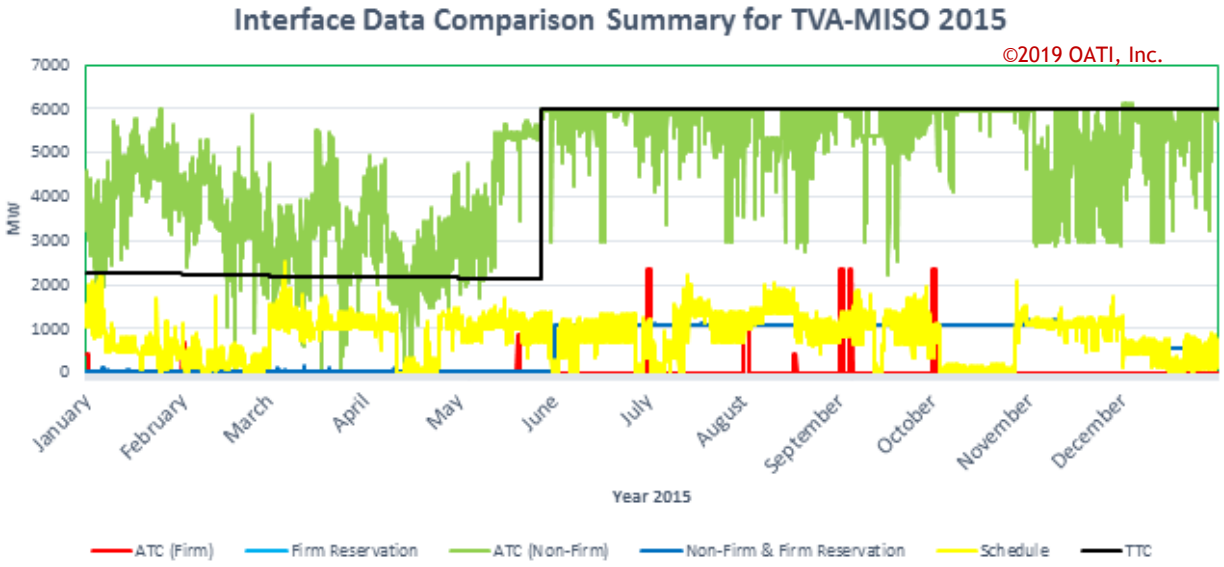


Figure 5.6-2d: Interface Comparison Summary for TVA > MISO

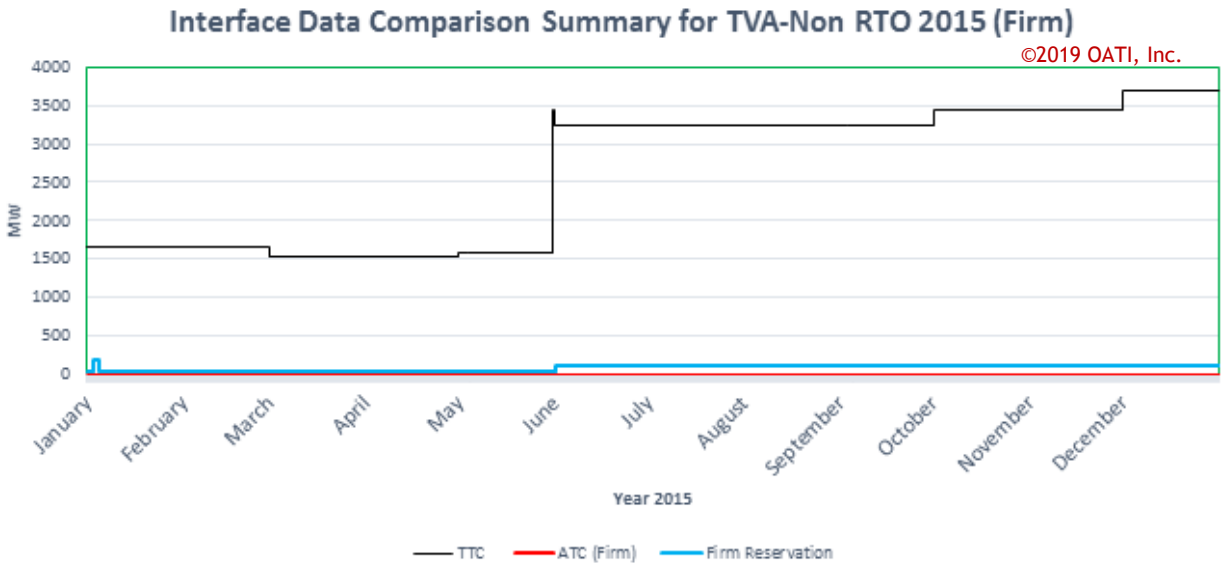


Figure 5.6-2e: Interface Firm OASIS Comparison Summary for TVA > Non RTO Midwest

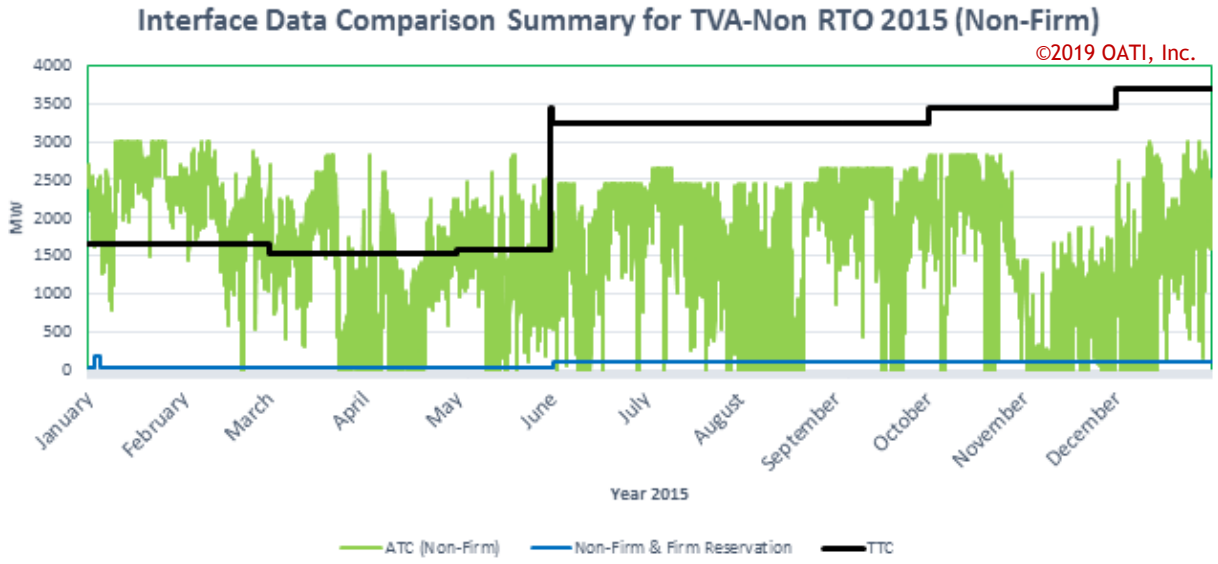


Figure 5.6-2f: Interface Non-Firm OASIS Comparison Summary for TVA > Non RTO Midwest

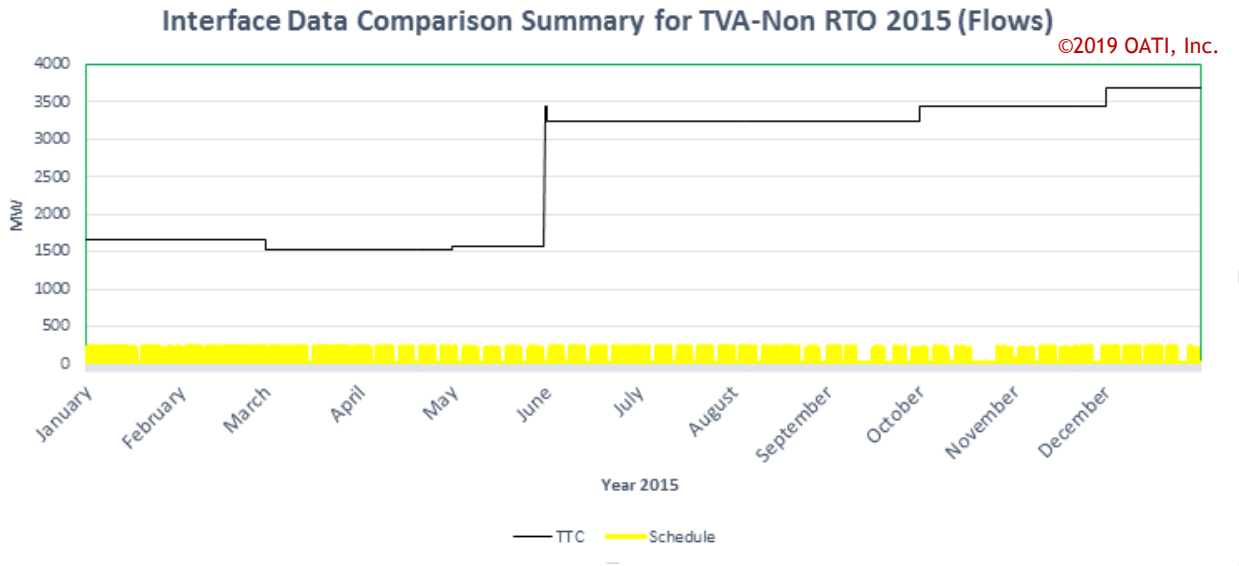


Figure 5.6-2g: Interface Flow Comparison Summary for TVA > Non RTO Midwest

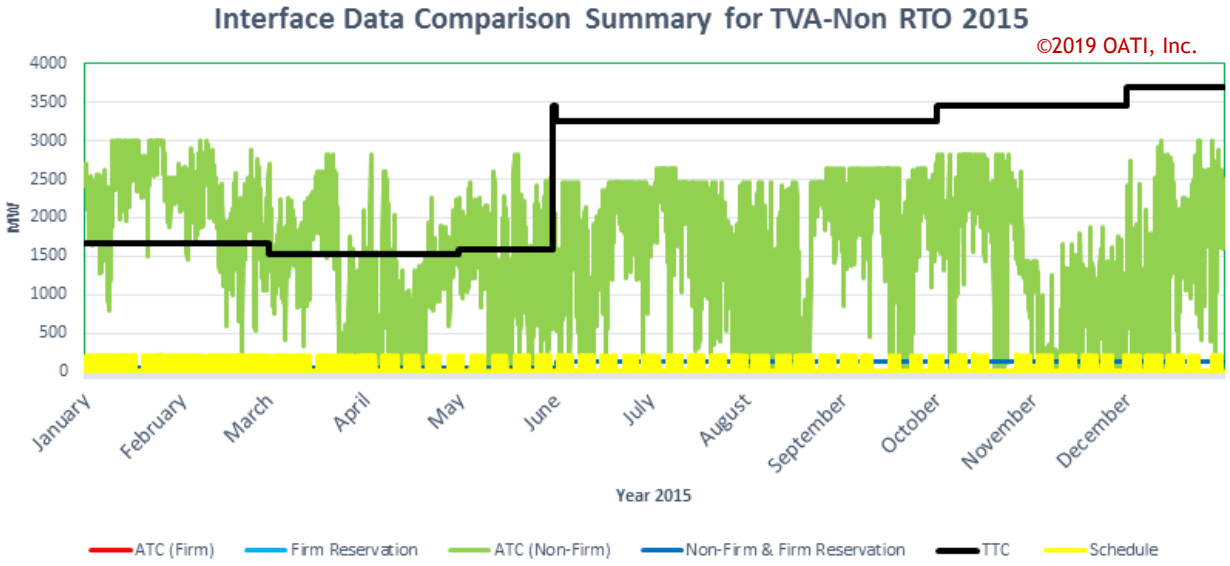


Figure 5.6-2h: Interface Comparison Summary for TVA > Non RTO Midwest

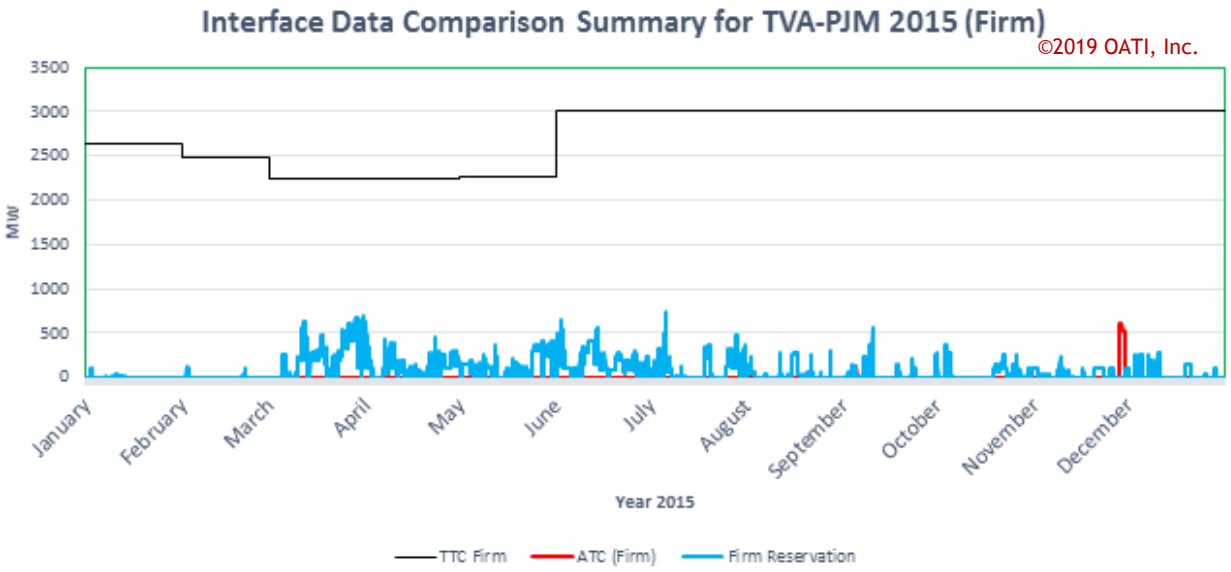


Figure 5.6-2i: Interface Firm OASIS Comparison Summary for TVA > PJM

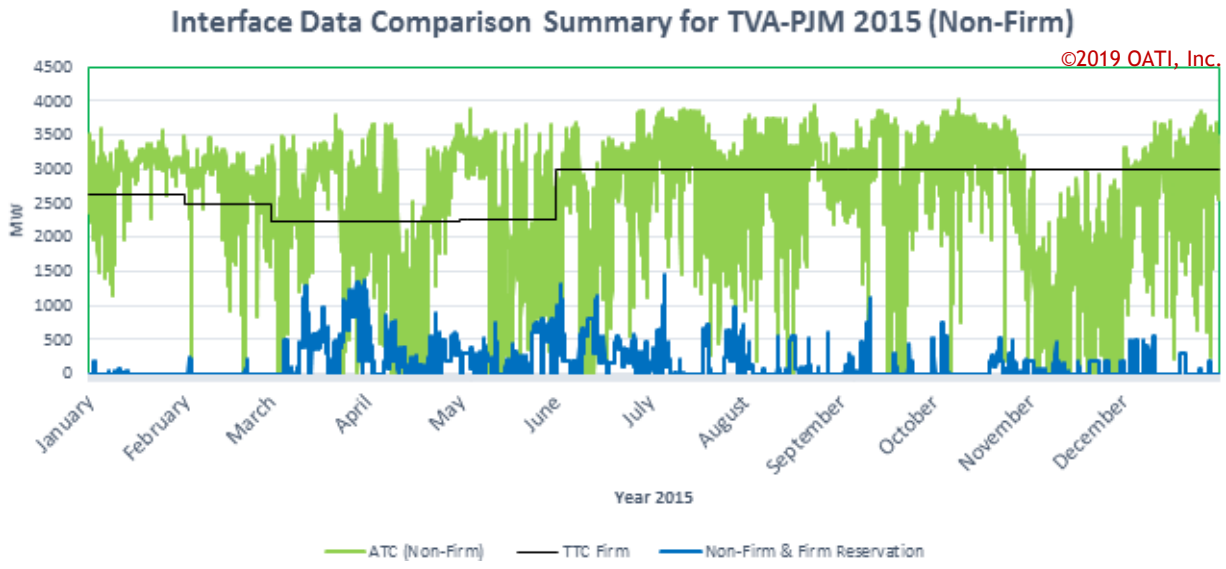


Figure 5.6-2j: Interface Non-Firm OASIS Comparison Summary for TVA > PJM

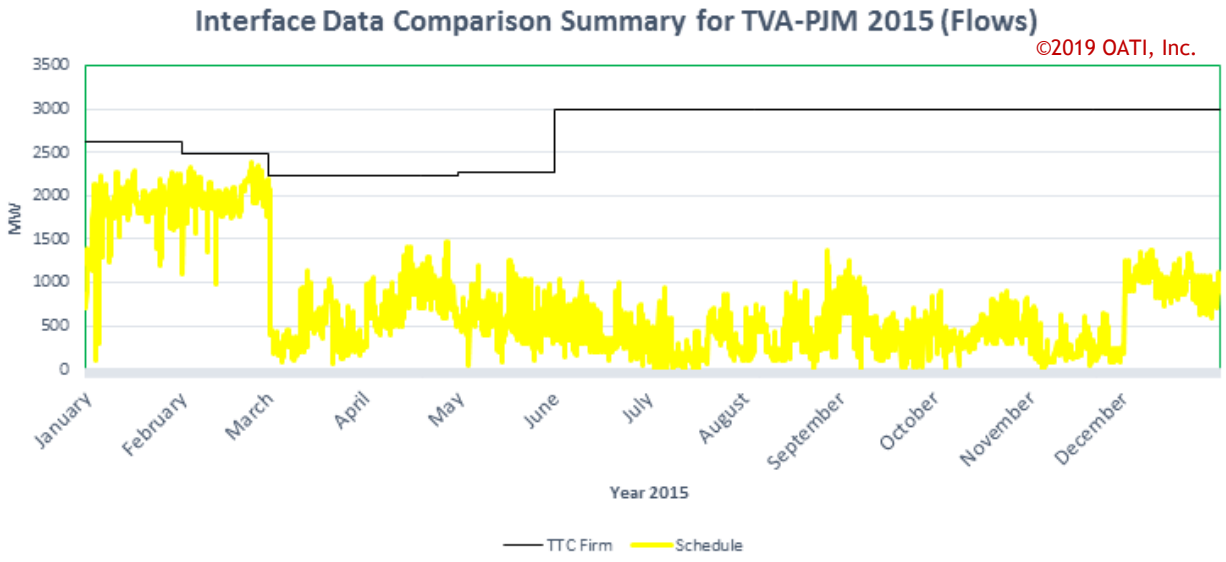


Figure 5.6-2k: Interface Flow Comparison Summary for TVA > PJM

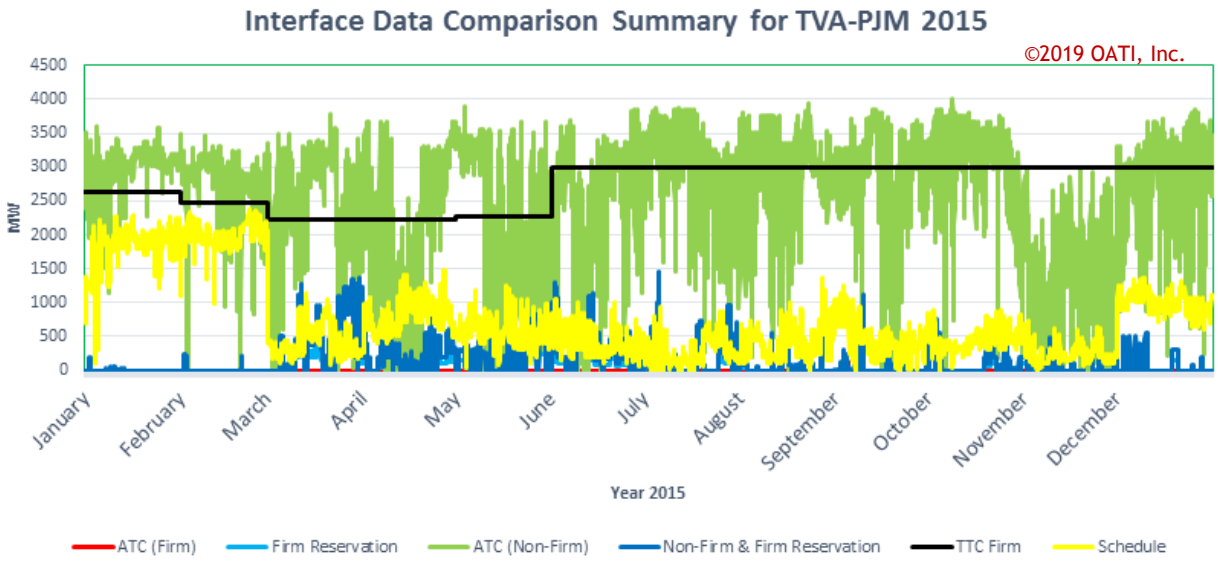


Figure 5.6-2l: Interface Comparison Summary for TVA > PJM

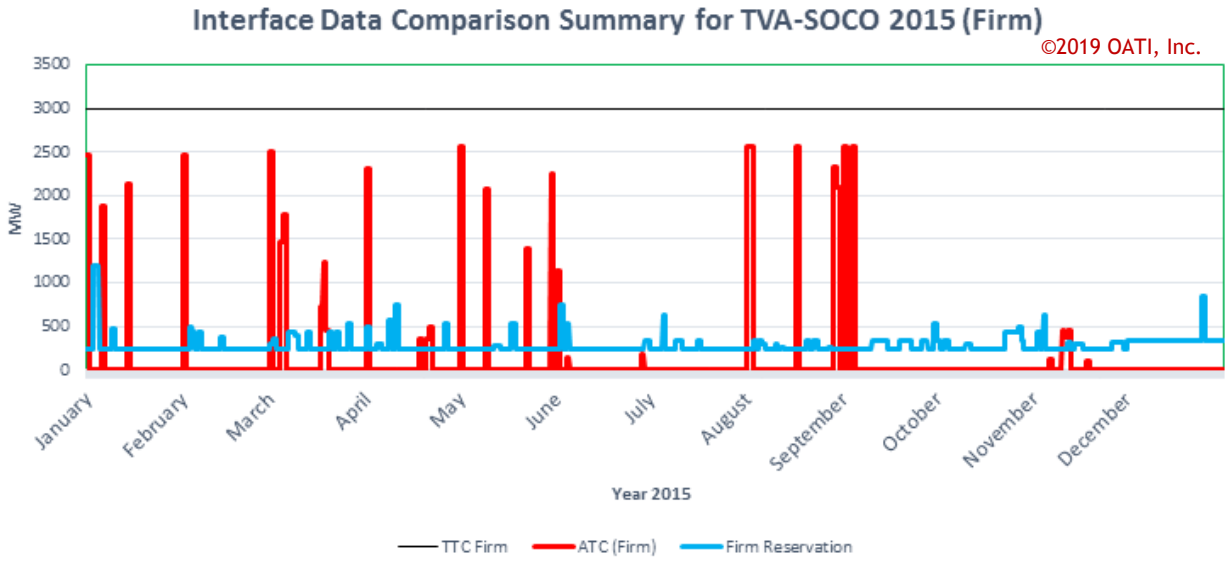


Figure 5.6-2m: Interface Firm OASIS Comparison Summary for TVA > SOCO

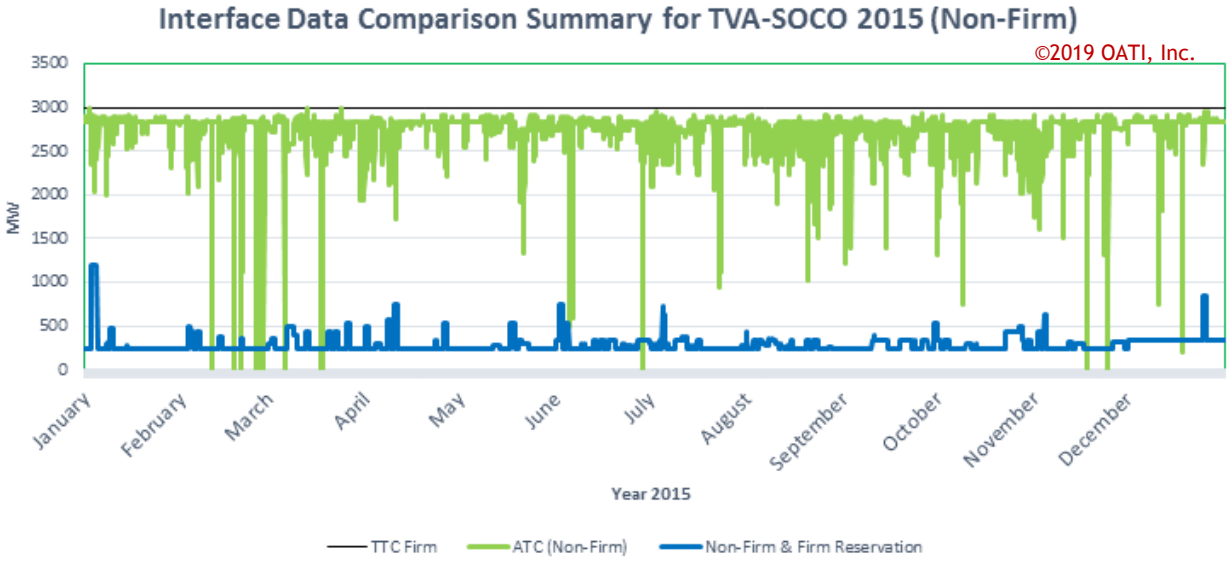


Figure 5.6-2n: Interface Non-Firm OASIS Comparison Summary for TVA > SOCO

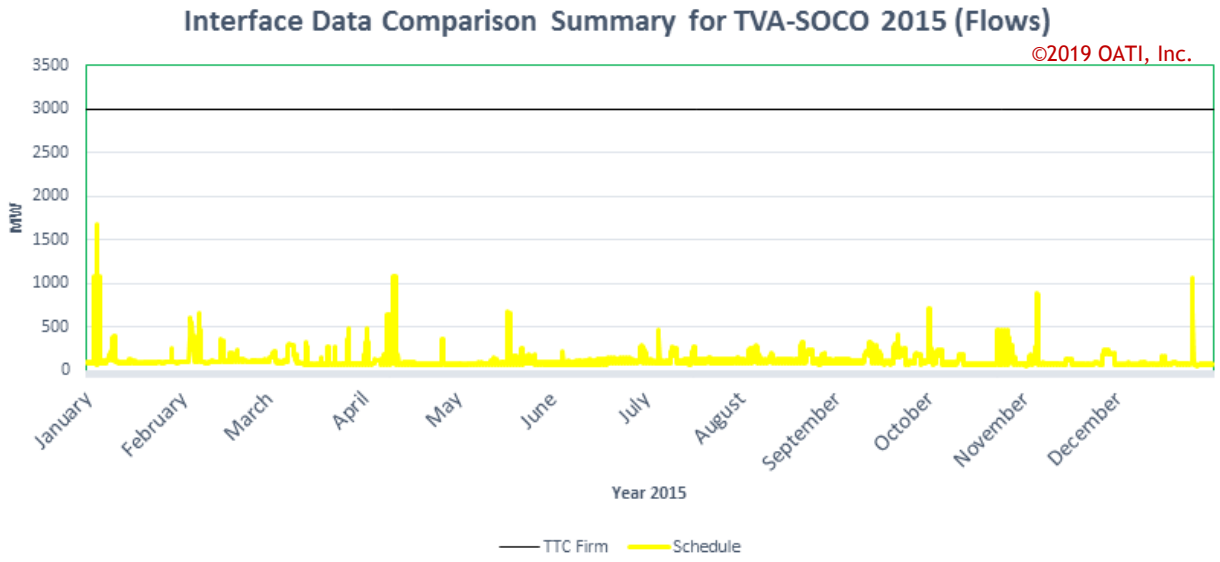


Figure 5.6-2o: Interface Flow Comparison Summary for TVA > SOCO

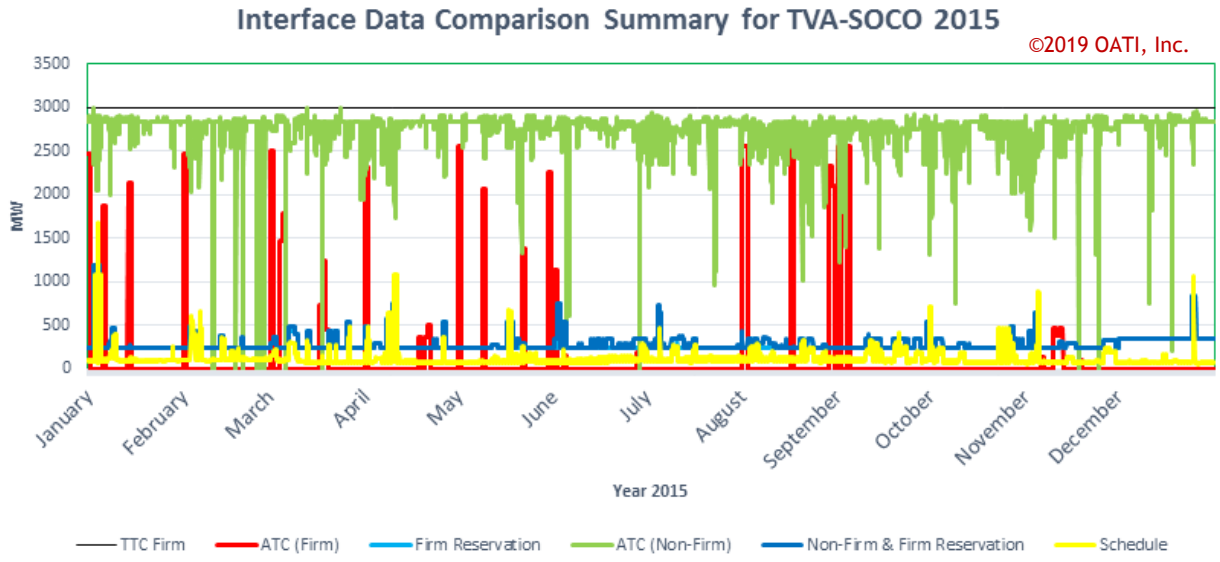


Figure 5.6-2p: Interface Comparison Summary for TVA > SOCO

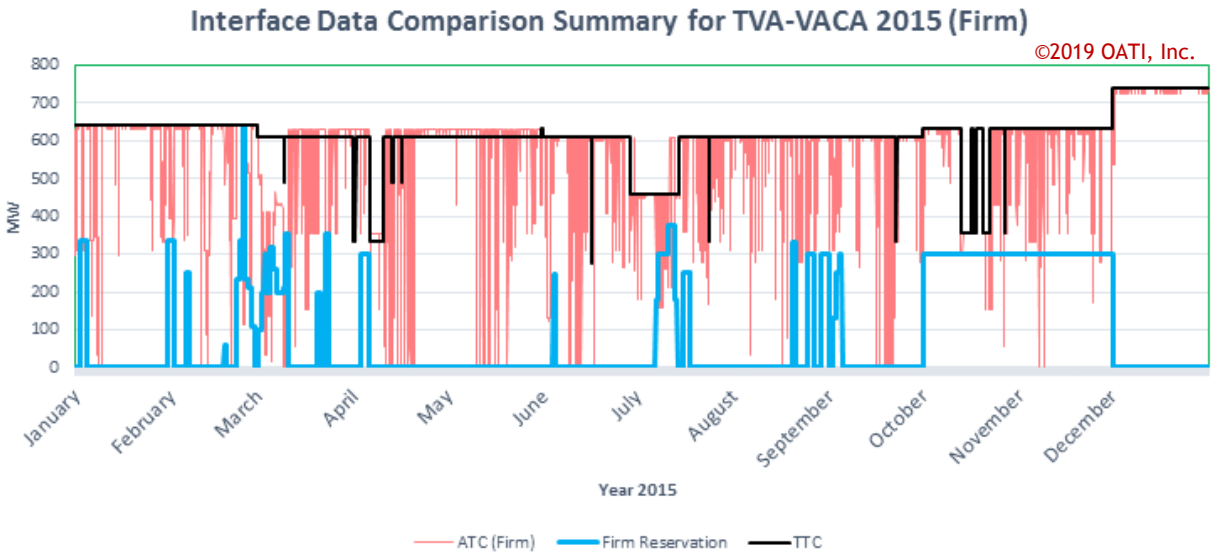


Figure 5.6-2q: Interface Firm OASIS Comparison Summary for TVA > VACAR

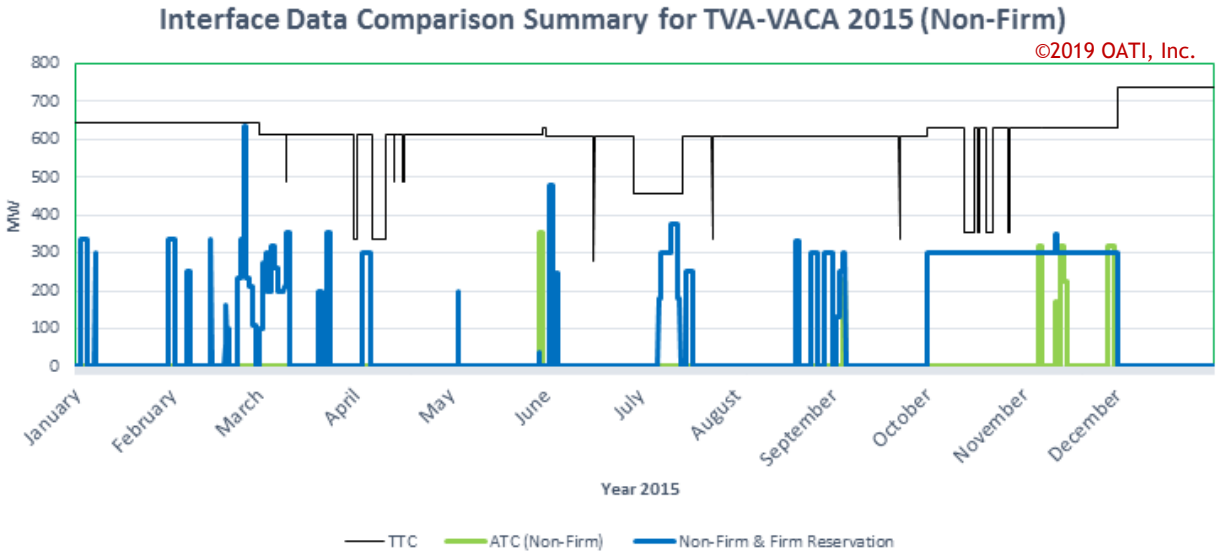


Figure 5.6-2r: Interface Non-Firm OASIS Comparison Summary for TVA > VACAR

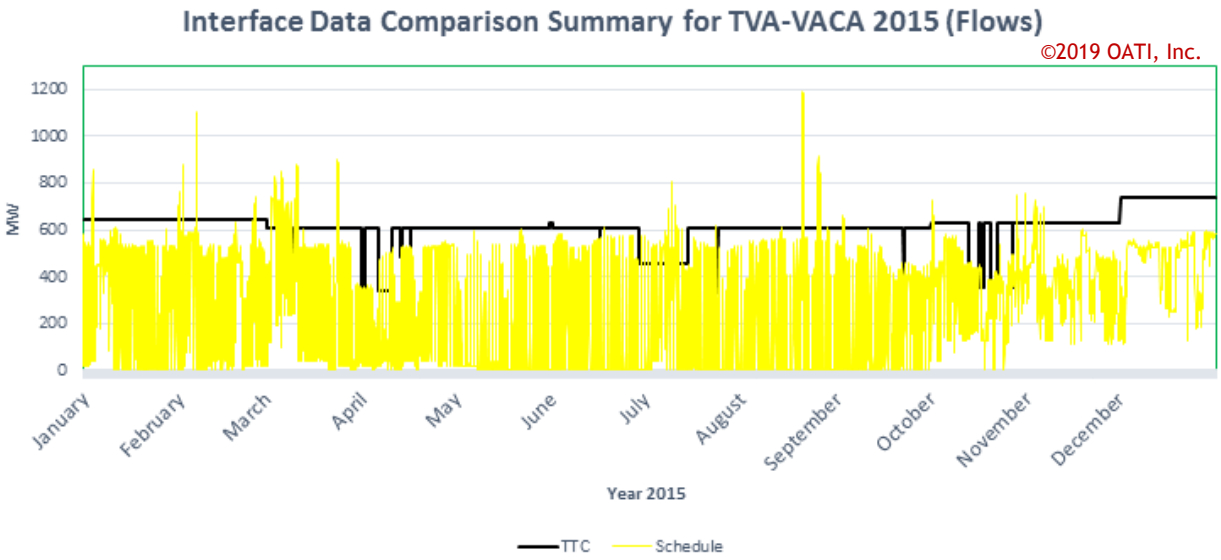


Figure 5.6-2s: Interface Flow Comparison Summary for TVA > VACAR

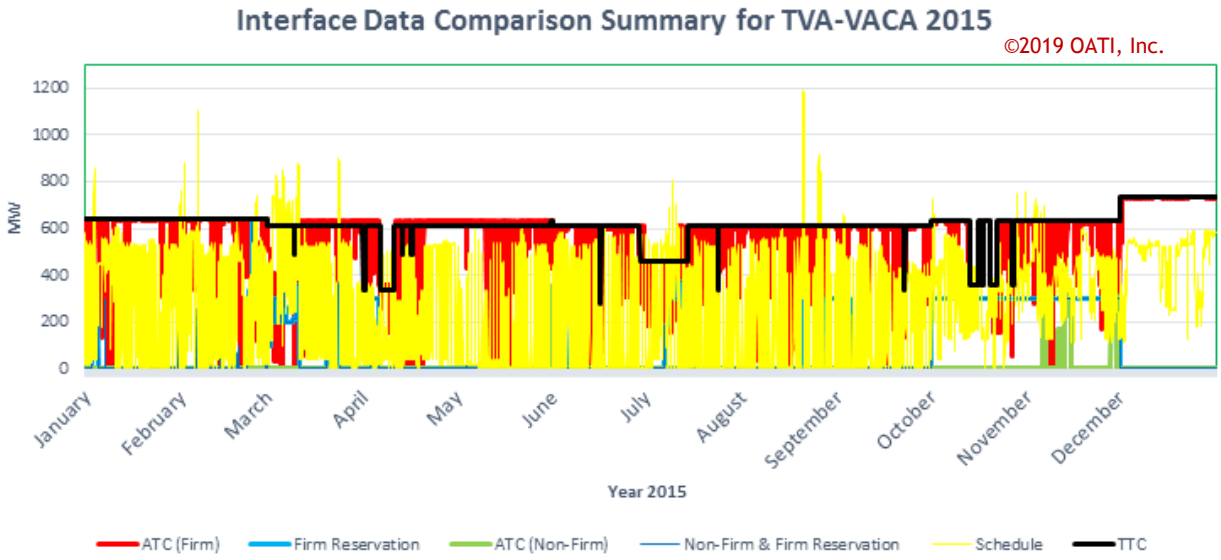


Figure 5.6-2t: Interface Comparison Summary for TVA > VACAR

5.6.4 TVA Study Metrics Summary

Both metrics for TVA sub-region and its interfaces between TVA and neighboring sub-regions are summarized in this section along with the study findings. Table 5.6-7a provides the interface summary related to TVA to visualize and compare its performance or limitations during reservations, scheduling and RT operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between TVA and other sub-regions. The top limiting flowgate for each interfaces due to TLR is also summarized in Table 5.6-7b.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule /Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
TVA > MISO	6/29 (5428/3)	30/22 (1870/45)	83.33/13.13 (25.63/92.37)	0/0	0/0	8520/6	97/174	21/49	11	0/30	0/127	0/59
MISO > TVA	17/149 (5454/39)	193/155 (2641/424)	**91.9/50.99** (32.63/91.56)	0/0	0/0	8493/4511	0/5	0/1	0	0/41	0/3523	0/79
TVA > SOCO	93/109 (2504/47)	137/94 (545/45)	59.56/46.31 (17.90/48.88)	0/0	0/0	7967/37	0/182	0/58	0	0/6	0/818	0/16
SOCO > TVA	**311/156** (603/306)	30/4 (95/0.09)	8.79/2.5 (13.67/0.03)	120/0	**70/0**	144/22	69/20	57/16	44	0/4	0/12	0/8
TVA > VACAR	55/14 (738/17)	59/8 (899/5378)	51.75/36.36 (54.90/99.67)	**222/24**	24/0	8568/170	**2451/0**	**838/0**	**447**	0/7	0/1203	0/13
VACAR > TVA	3/66 (8/22)	0/2 (0/0.082)	0/2.94 (0/0.36)	0/0	0/0	400/171	0/0	0/0	0	0/0.43	0/33	0/1
TVA > PJM	210/1038 (3544/648)	**1660/733 (145767/1320)**	88.77/41.39 **(97.6/67.07)**	0/0	0/0	8687/228	869/0	60/0	0	**0/162**	**0/12073**	**0/328**
PJM > TVA	29/317 **(9454/196)**	13/0 (N/A)	30.90/0 (N/A)	0/0	0/0	3384/270	0/0	0/0	0	0/0	0/0	0/0
TVA > NON RTO MIDWEST	3/0 (821/0)	2/8 (3/4)	40/0 (0.41/100)	0/0	0/0	**8760/946**	0/0	0/0	0	0/10	0/174	0/20
NON RTO MIDWEST > TVA	19/96 (7/21)	17/20 (0/4)	47.2/17.24 (0/15.94)	0/0	0/0	1280/130	0/0	0/0	0	0/29	0/171	0/14

Table 5.6-7a: TVA Interface Summary

Top limiting flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
TVA > MISO	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	41
TVA > SOCO	None	0	Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	16
TVA > VACAR	None	0	Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	9
TVA > PJM	None	0	**Person-Halifax 230 kV line l/o Wake-Carson 500 kV**	**82**
TVA > NON RTO MIDWEST	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	14

Table 5.6-7b: TVA TLR top flowgates

Based on the above summary results, the following observations are noted.

1. The TVA-PJM interface is the one of the most limiting interface in TVA based on refused TSR count, refused TSR reservation GWh, TLR duration, TLR MWh and TLR count. The TVA-Non RTO Midwest is most limiting based on Zero ATC count.
2. The PJM-TVA is the most reserved interface based on confirmed reservation GWh.
3. The TVA-VACAR interface is the most loaded interface during RT in TVA based on U90 (schedule). It should be noted that the actual flows are not reported on any of the interfaces as it was not provided by TVA. Schedules may not always represent actual because of the RT configuration of the system as well as the fact that GTL schedules may not be reported.
4. No firm TLRs were called on interfaces from or to TVA; however, non-firm TLRs were called on almost all interfaces. The top limiting TLR flowgate was Person-Halifax 230 kV line l/o Wake-Carson 500 kV on TVA-PJM.

The TVA sub-region metrics are summarized below. Table 5.6-7c provides a TLR summary for the TVA sub-region.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
TVA	0/215	0/17583	0/436

Table 5.6-7c: TVA TLR Sub-Region Summary

TVA	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	111

Table 5.6-7d: TVA Top Limiting Flowgate for TLR

No firm TLRs were called on Interfaces in the TVA sub-region; however, non-firm TLRs were called, and the Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV flowgate had the most TLRs called upon it.

5.7 SOCO

5.7.1 Sub-Region Metrics

5.7.1.1 TLR Metrics

This study also developed TLR metrics for the SOCO sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

SOCO	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
	0	0	0	169	5141	277

Table 5.7-1a: TLR Metrics for the SOCO Sub-Region

Sub-region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
SOCO	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	127	2232
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	61	1771
				Widows Creek 500/161 bank flo Browns Ferry-Maury 500kv	61	556
				McIntosh (SAV) - Hardeeville (SCEG) 115kV flo McIntosh (SAV) - Purrysburg (SC) 230kV	9	193
				Widows Creek - Sequoyah 500kV Line	7	307

Table 5.7-1b: Top Five Limiting Flowgates (Count-Based) for the SOCO Sub-Region

5.7.2 Interface Metrics

5.7.2.1 Transmission Service Request Metric

These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces. The results from the TSR metric for the SOCO interfaces are provided in Tables 5.7-2a through 5.7-2d.

Interface	Firm Confirmed TSR count	Firm Refused TSR count	% Refusal
SOCO > TVA	311	30	8.80%
TVA > SOCO	93	137	59.56%
SOCO > MISO	942	53	5.33%
MISO > SOCO	9	102	91.89%
SOCO > VACAR	3121	79	2.47%
VACAR > SOCO	263	10	3.66%

Table 5.7-2a: Firm Confirmed and Refused TSR Count

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
SOCO> TVA	156	4	2.50%
TVA > SOCO	109	94	46.31%
SOCO > MISO	254	21	7.64%
MISO > SOCO	275	130	32.10%
SOCO > VACAR	175	1	0.57%
VACAR > SOCO	3752	8	0.21%

Table 5.7-2b: Non-Firm Confirmed and Refused TSR Count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
SOCO > TVA	603806	95616	13.67
TVA > SOCO	2504032	545876	17.90
SOCO > MISO	3396428	228864	6.31
MISO > SOCO	2826898	1264424	30.91
SOCO > VACAR	13900708	2071275	12.97
VACAR > SOCO	760938	169896	18.25

Table 5.7-2c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
SOCO > TVA	306405	93	0.03
TVA > SOCO	47584	45503	48.88
SOCO > MISO	22057	2725	11.00
MISO > SOCO	48531	1264424	96.30
SOCO > VACAR	20548	159635	88.60
VACAR > SOCO	1129995	1574	0.14

Table 5.7-2d: Non-Firm Confirmed and Refused Reservation MWh

5.7.2.2 Transmission Reservation Utilization Metric

The results from the Transmission Service Utilization metric for the SOCO interfaces are provided in Tables 5.7-3a and 5.7-3b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
SOCO > TVA	120	0
TVA > SOCO	0	0
SOCO > MISO	683	0
MISO > SOCO	0	0
SOCO > VACAR	97	0
VACAR > SOCO	0	0

Table 5.7-3a: TRU75 for Firm and Non-Firm Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
SOCO > TVA	72	0
TVA > SOCO	0	0
SOCO > MISO	347	0
MISO > SOCO	0	0
SOCO > VACAR	40	0
VACAR > SOCO	0	0

Table 5.7-3b: TRU90 for Firm and Non-Firm Reservation

5.7.2.3 Zero ATC Metric

The results from the ATC metric for SOCO interfaces are provided in Table 5.7-4.

Interface	Zero ATC Count: Firm	Zero ATC Count: Non-Firm
SOCO > TVA	144	22
TVA > SOCO	7967	37
SOCO > MISO	233	207
MISO > SOCO	8440	1506
SOCO > VACAR	9	6
VACAR > SOCO	0	0

Table 5.7-4: Zero ATC Count

This study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.7-1 through 5.7-1d).

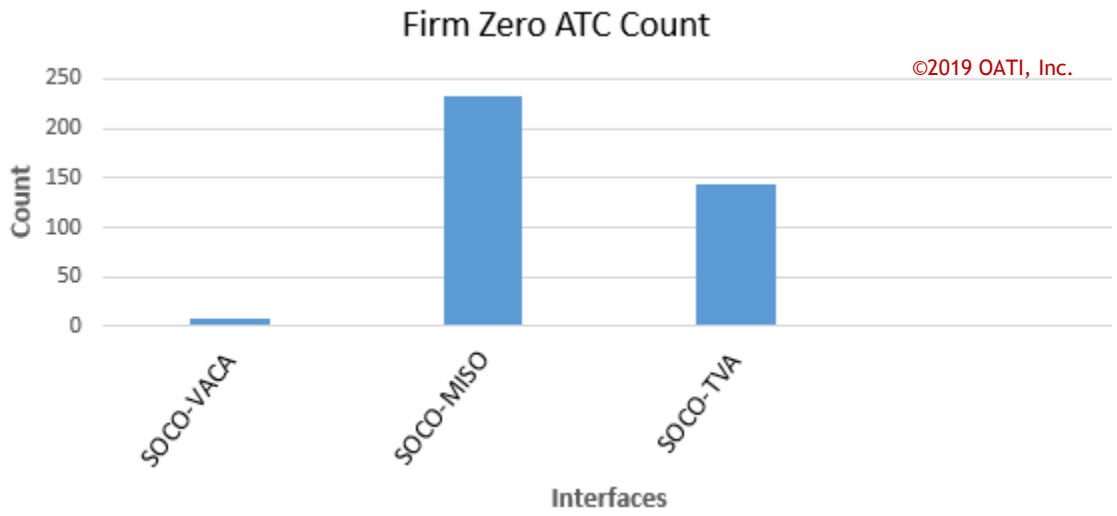


Figure 5.7-1a: Firm Zero ATC Count

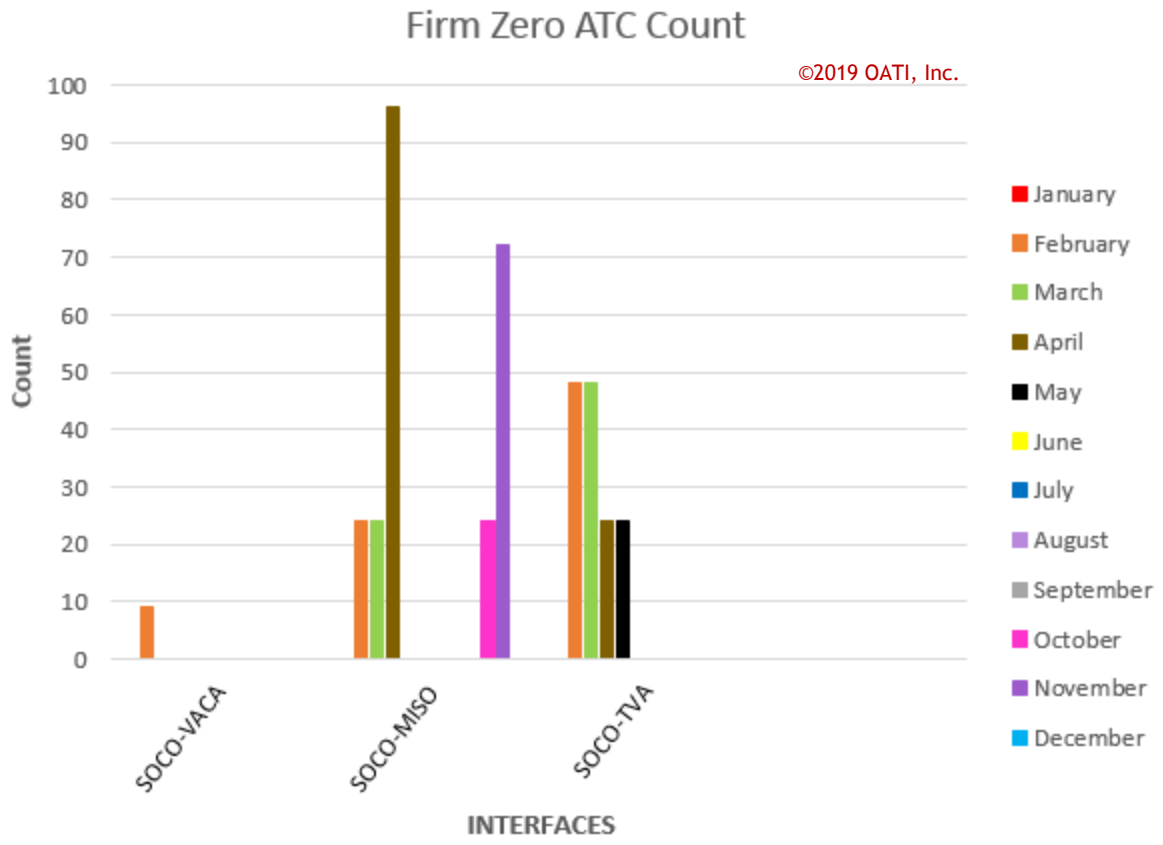


Figure 5.7-1b: Firm Zero ATC Count

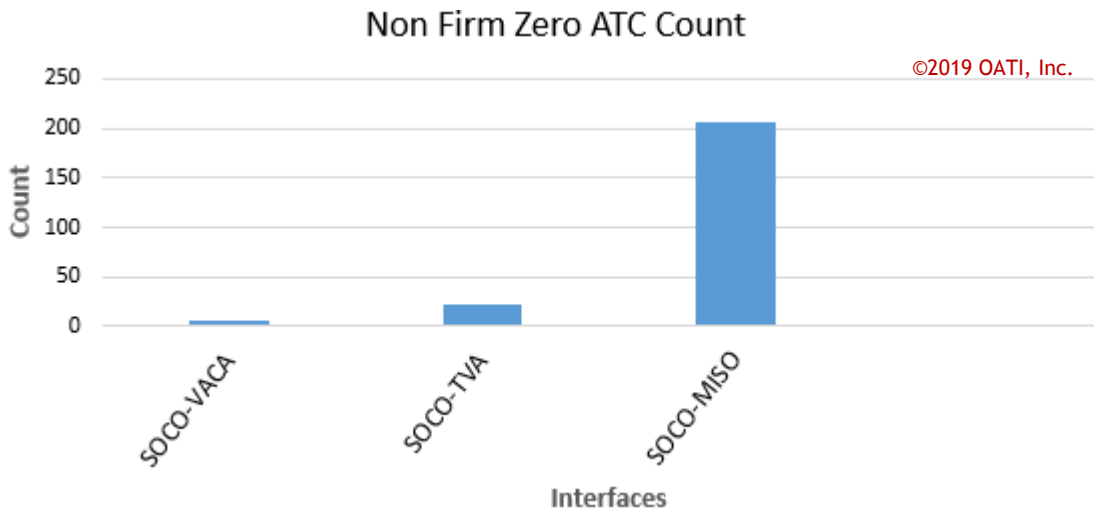


Figure 5.7-1c: Non-Firm Zero ATC Count

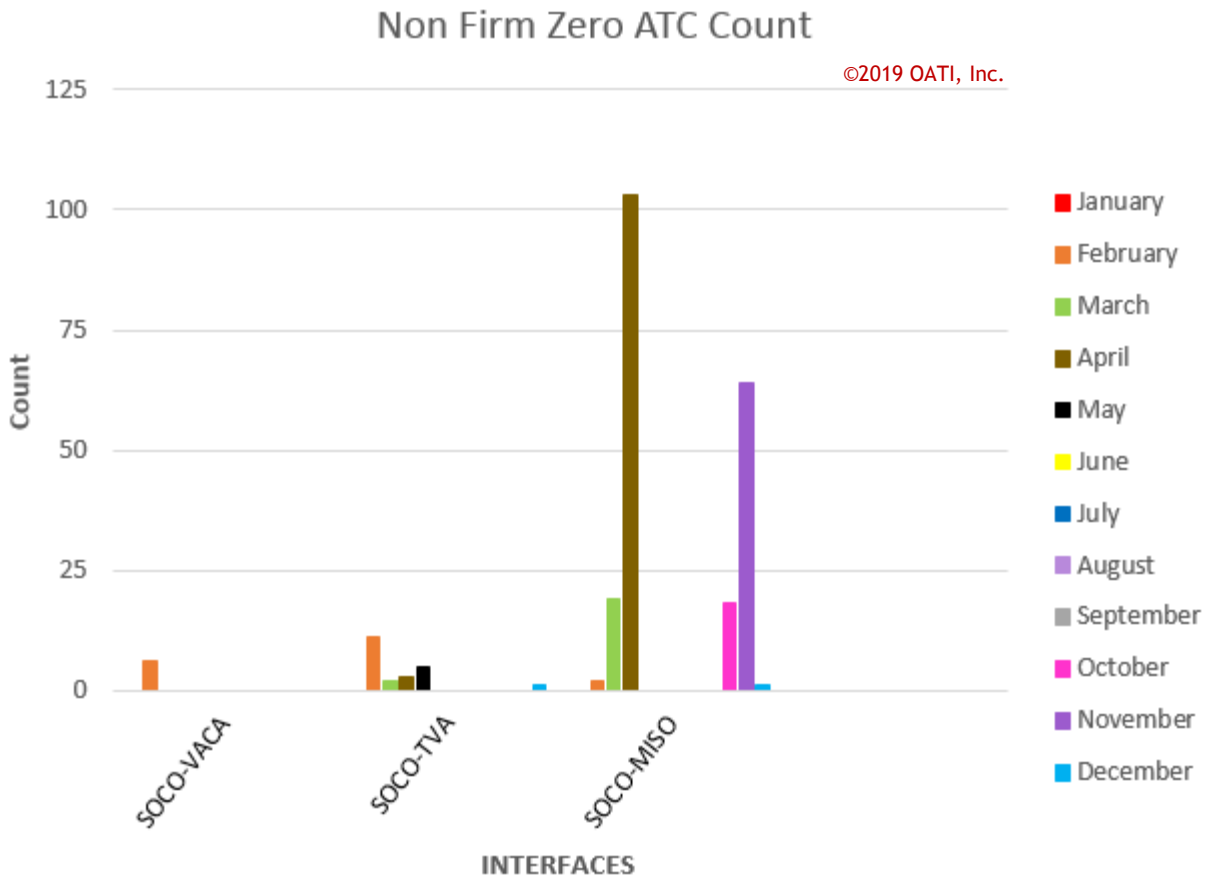


Figure 5.7-1d: Non-Firm Zero ATC Count

5.7.2.4 Schedule Utilization Metrics and Actual Flow Metrics

Schedule utilization metrics and actual flow metrics were calculated for the interfaces. The utilization metric U75 provides the total yearly count for an interface where the hourly scheduled flow exceeded 75 percent of the TTC. The utilization metric U90 provide the total yearly count for an interface where the hourly schedule/flow exceeded 90 percent of the TTC.

The results from schedule utilization metrics and actual flow metrics for the interfaces are provided in Tables 5.7-5a through 5.7-5d.

Interface	U75 Schedule Count	U90 Schedule Count
SOCO > TVA	161	74
TVA > SOCO	0	0
SOCO > MISO	608	287
MISO > SOCO	0	0
SOCO > VACAR	49	2
VACAR > SOCO	0	0

Table 5.7-5a: Scheduled Flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
SOCO > TVA	20	16
TVA > SOCO	182	58
SOCO > MISO	890	573
MISO > SOCO	0	0
SOCO > VACAR	55	6
VACAR > SOCO	2	0

Table 5.7-5b: Actual flow Utilization Metric

A metrics for interfaces based on a schedule count above the TTC were also developed. The results for the metric are provided in Table 5.7-5c.

Interface	Schedule Count above TTC
SOCO > TVA	44
TVA > SOCO	0
SOCO > MISO	193
MISO > SOCO	0
SOCO > VACAR	0
VACAR > SOCO	0

Table 5.7-5c: Schedule Count above TTC

5.7.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metric for the interfaces are provided in Tables 5.7-6a and 5.7-6b.

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
SOCO > TVA	0	0	0	4	12	8
TVA > SOCO	0	0	0	6	818	16
SOCO > MISO	0	0	0	4	190	8
MISO > SOCO	0	0	0	55	2522	110
SOCO > VACAR	0	0	0	161	4939	261
VACAR > SOCO	0	0	0	0	0	0

Table 5.7-6a: TLR Metrics for SOCO Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
SOCO > TVA	None	0	0	Widows Creek 500/161 bank flo Browns Ferry-Maury 500kV	8	12
SOCO > MISO	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	8	190
SOCO > VACAR	None	0	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	119	2042
				Volunteer - Phipps Bend 500 FLO Conasauga - Mosteller 500	61	1771
				Widows Creek 500/161 bank flo Browns Ferry-Maury 500kv	53	544
				McIntosh (SAV) - Hardeeville (SCEG) 115kV flo McIntosh (SAV) - Purrysburg (SC) 230kV	9	193
				Widows Creek - Sequoyah 500kV Line	7	307

Table 5.7-6b: Top Five Limiting Flowgates (Count-Based) for SOCO Interfaces

5.6.1 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all the study interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

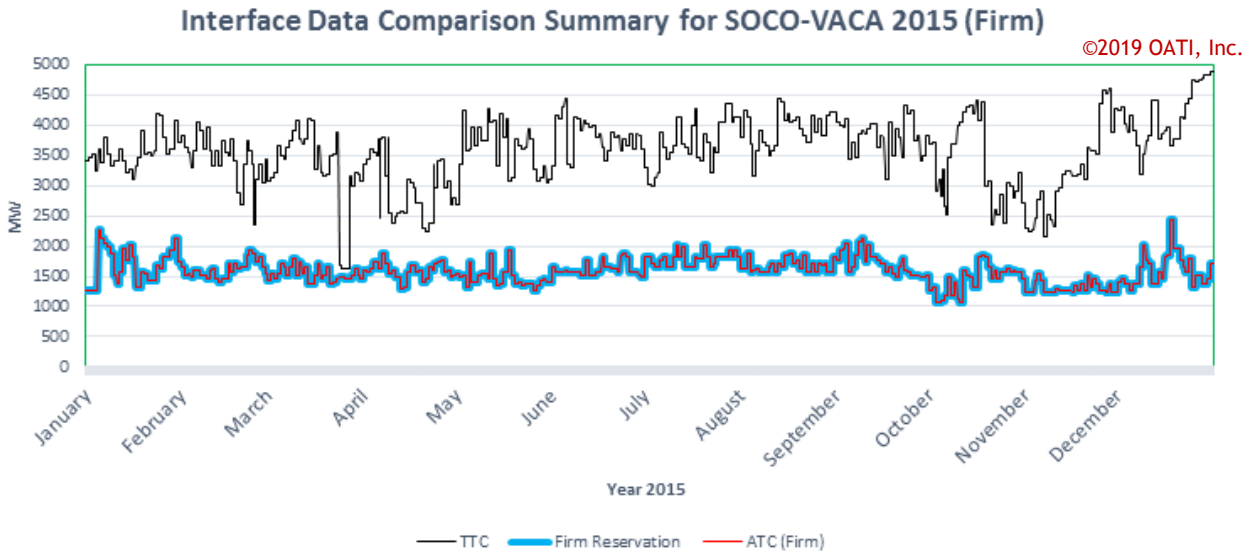


Figure 5.7-1a: Interface Firm OASIS Comparison Summary for SOCO > VACAR 2015

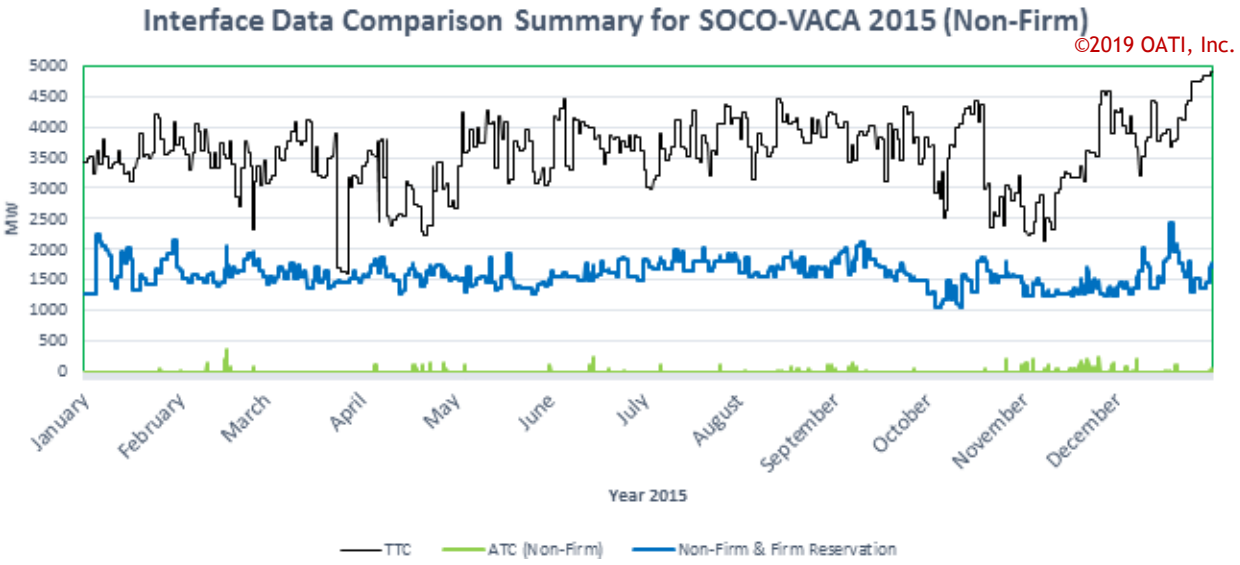


Figure 5.7-1b: Interface Non-Firm OASIS Comparison Summary for SOCO > VACAR 2015

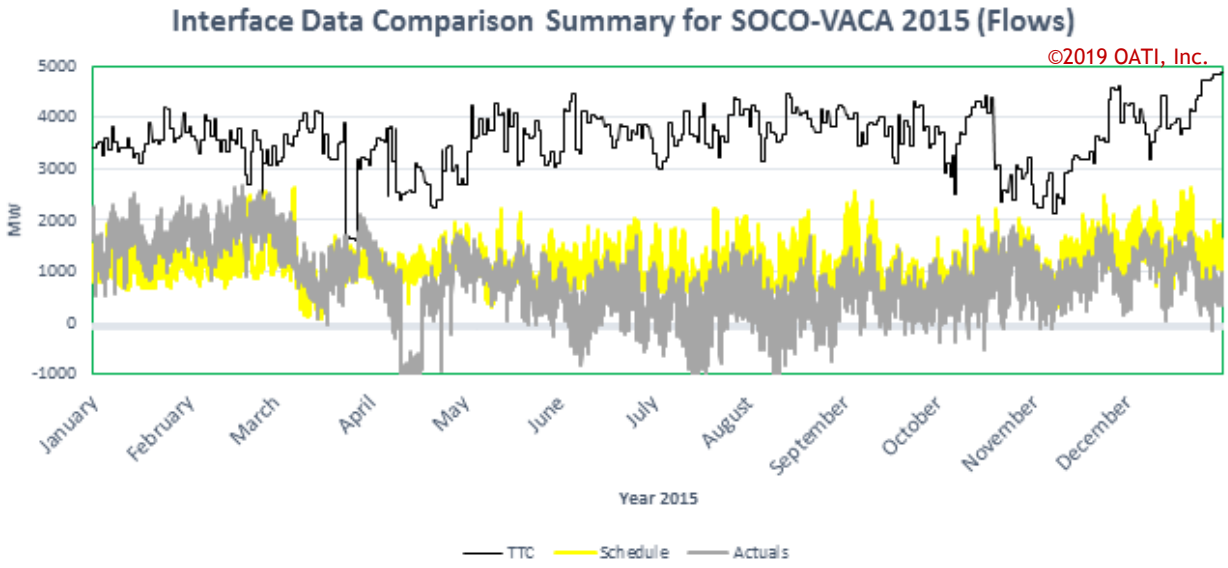


Figure 5.7-1c: Interface Flow Comparison Summary for SOCO > VACAR 2015

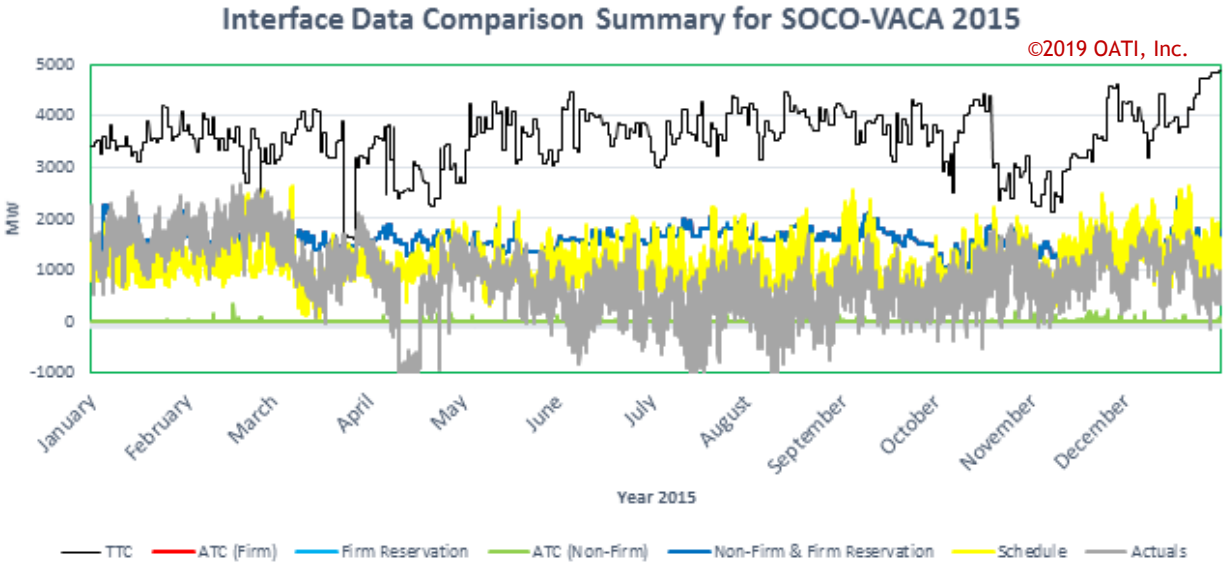


Figure 5.7-1d: Interface Comparison Summary for SOCO > VACAR 2015

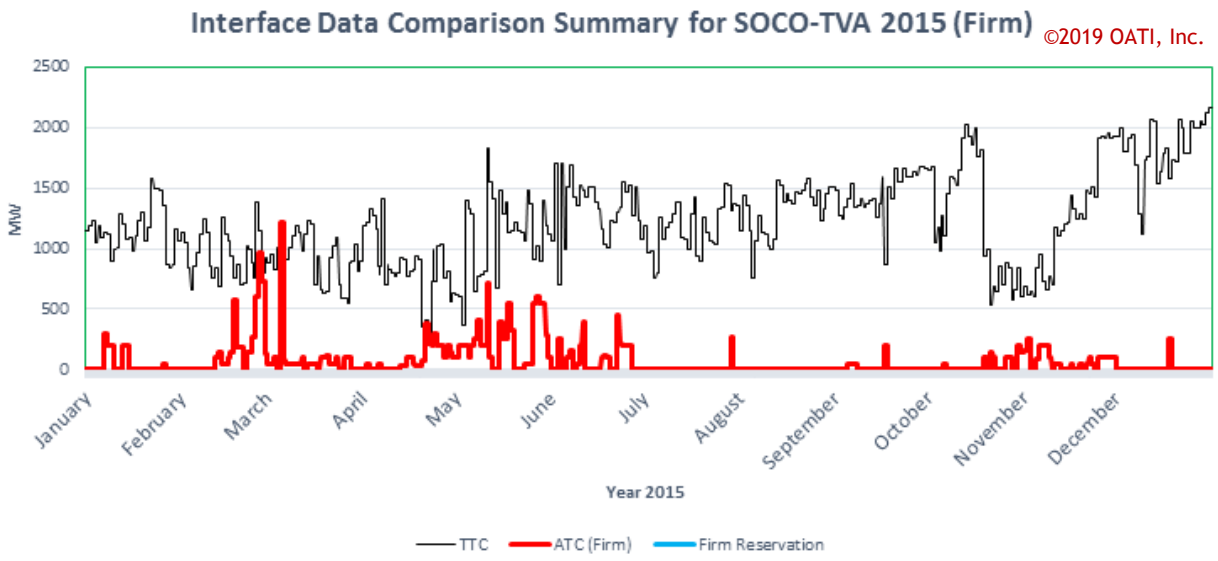


Figure 5.7-1e: Interface Firm OASIS Comparison Summary for SOCO > TVA 2015

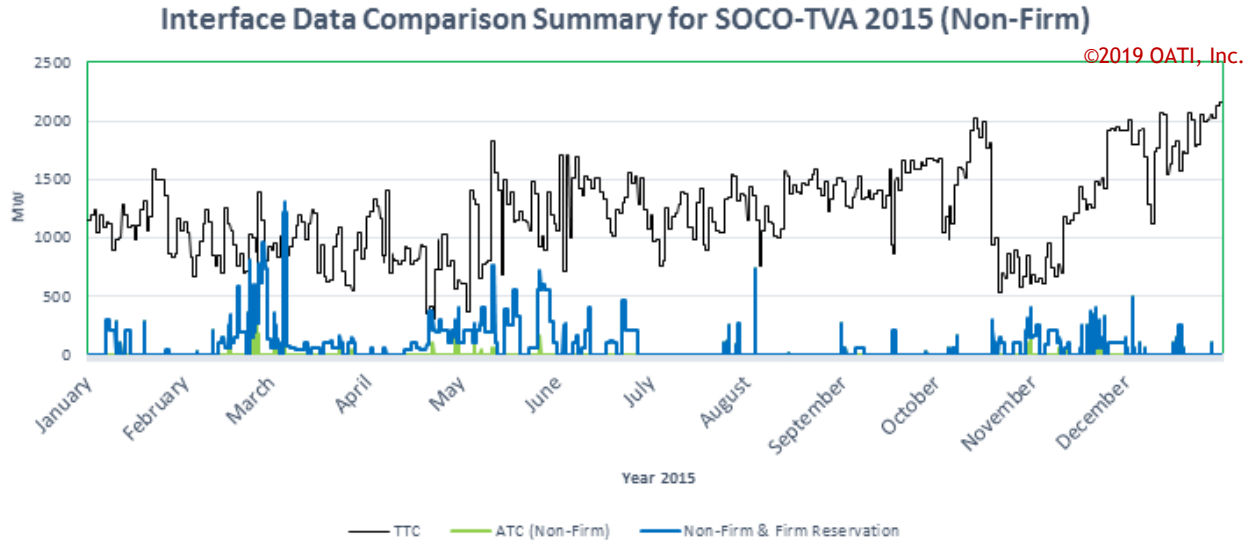


Figure 5.7-1f: Interface Non-Firm OASIS Comparison Summary for SOCO > VACAR 2015

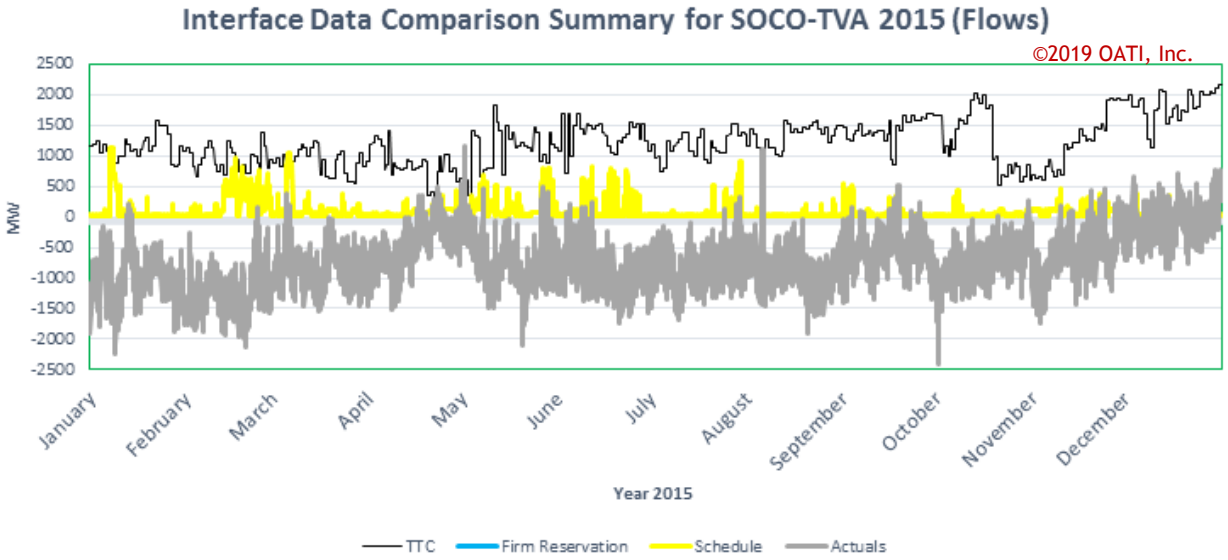


Figure 5.7-1g: Interface Flow Comparison Summary for SOCO > VACAR 2015

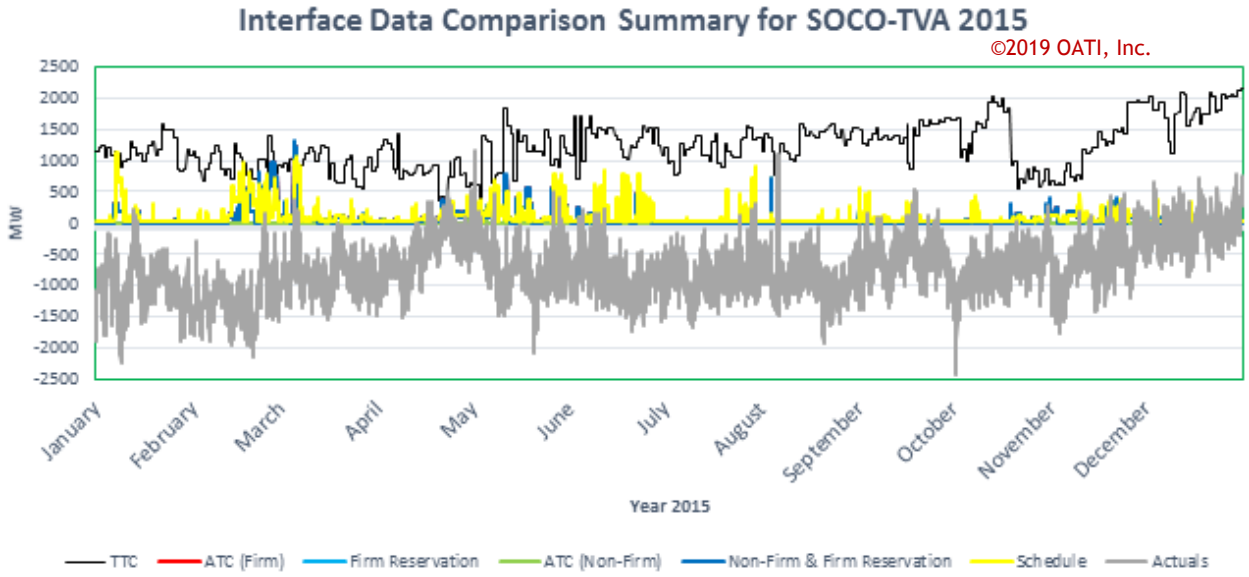


Figure 5.7-1h: Interface Comparison Summary for SOCO > VACAR 2015

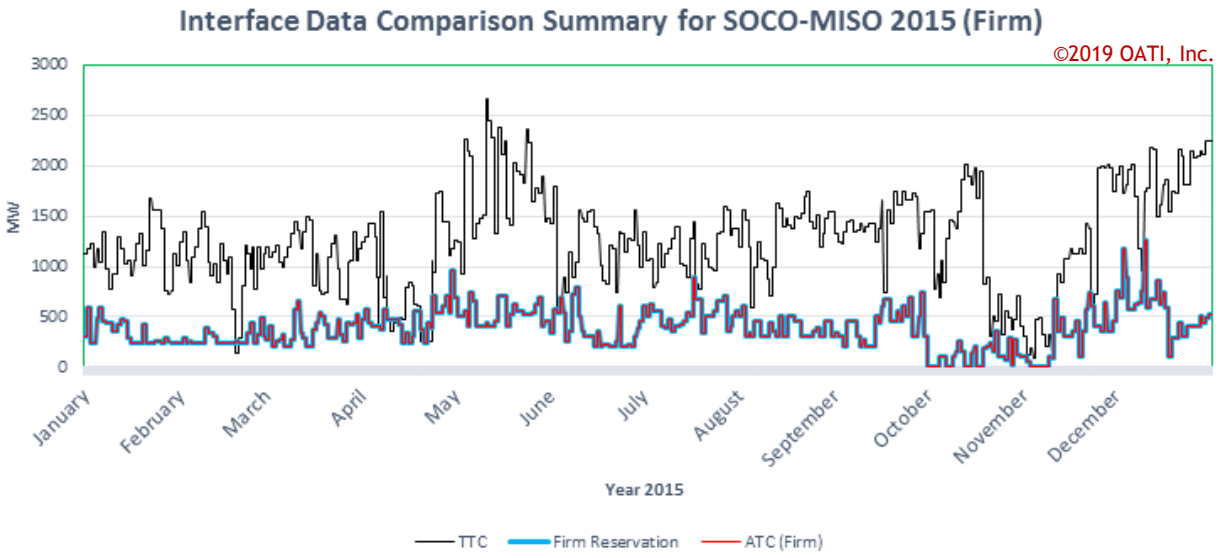


Figure 5.7-1i: Interface Firm OASIS Comparison Summary for SOCO > MISO 2015

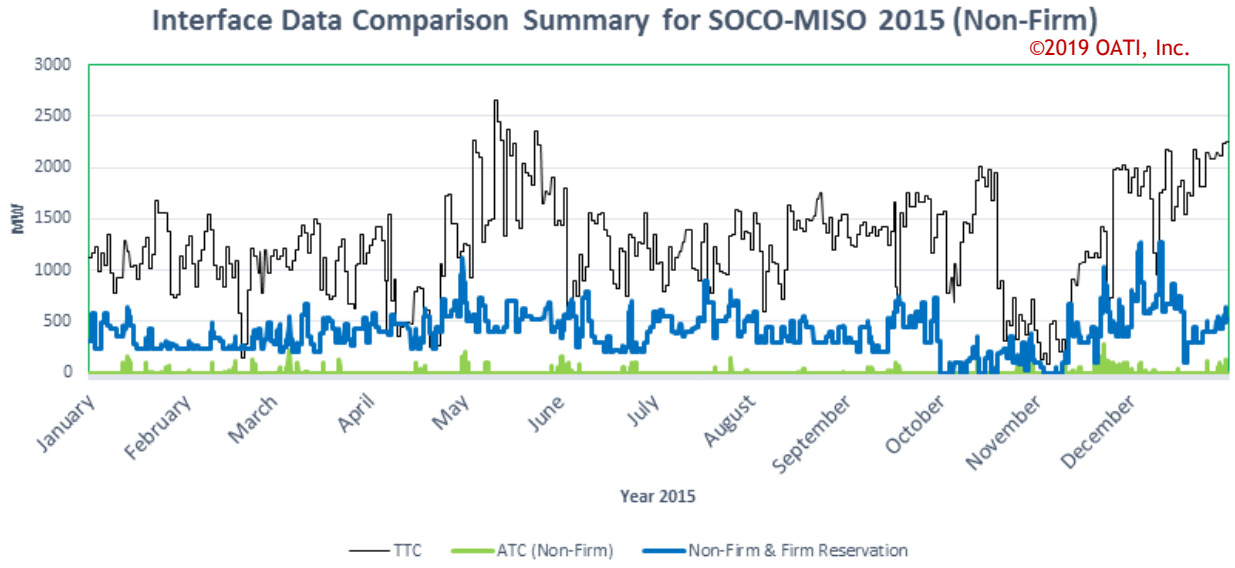


Figure 5.7-1j: Interface Non-Firm OASIS Comparison Summary for SOCO > MISO 2015

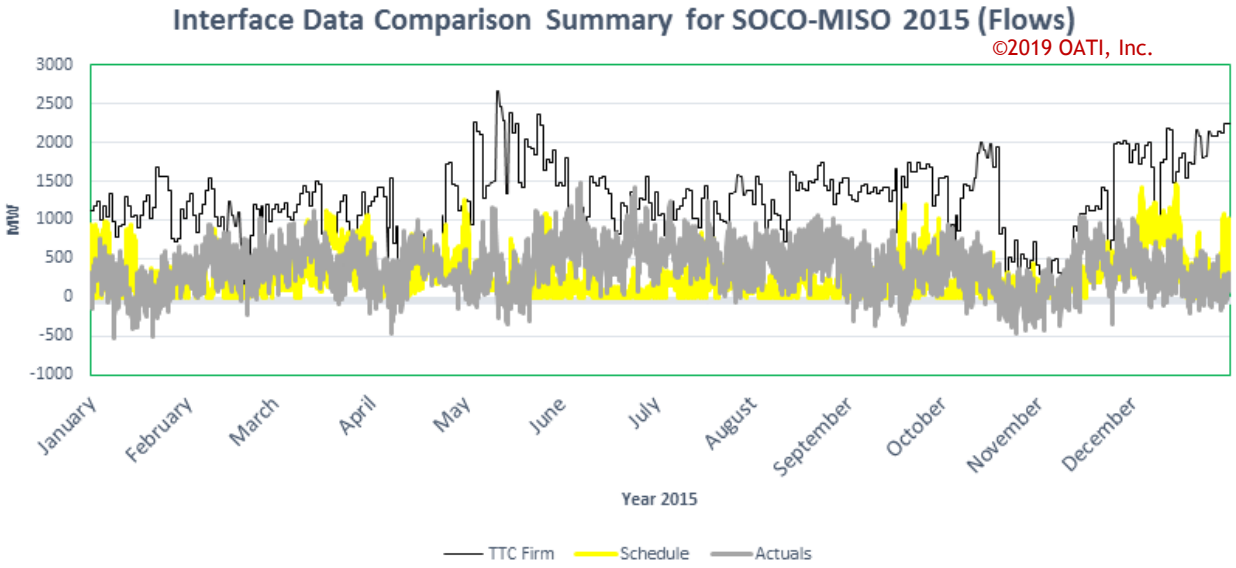


Figure 5.7-1k: Interface Flow Comparison Summary for SOCO > MISO 2015

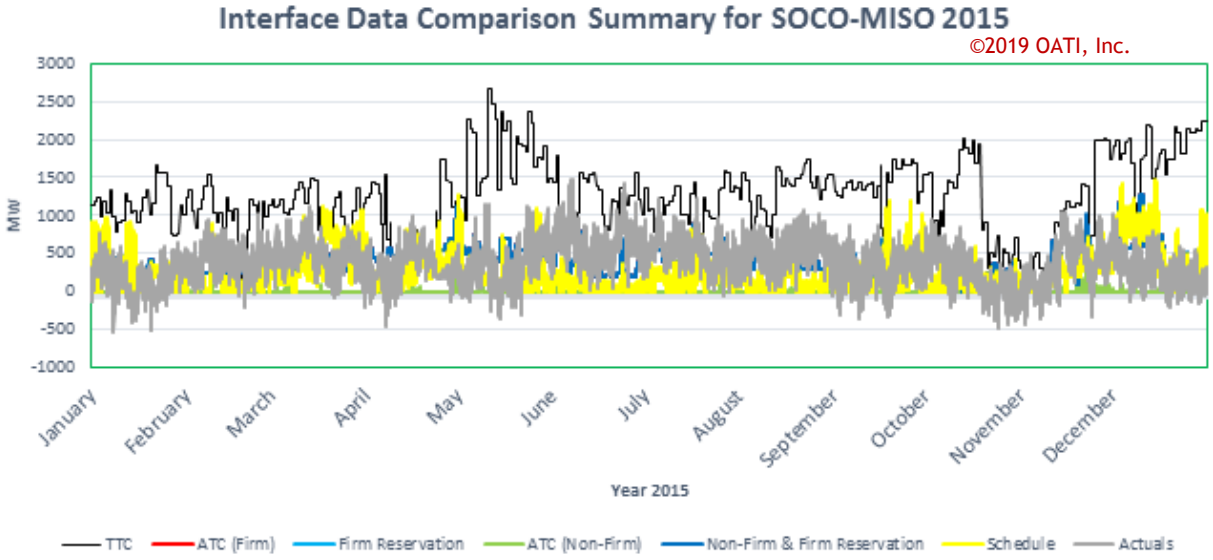


Figure 5.7-1l: Interface Comparison Summary for SOCO > MISO 2015

5.7.3 SOCO Study Metrics Summary

Both metrics for the SOCO sub-region and its interfaces between SOCO and neighboring sub-regions are summarized in this section along with the study findings. Table 5.7-7a provides the interface summary related to SOCO to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below represent the highest metric values among all interfaces between SOCO and other sub-regions. The top limiting flowgate for each interfaces due to TLR is also summarized in Table 5.7-7b.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule /Actual Yearly Count	U90 Schedule /Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
SOCO > TVA	311/156 (603/306)	30/4 (95/0.09)	8.79/2.5 (13.67/0.03)	120/0	72/0	144/22	161/20	74/16	**44**	0/4	0/12	0/8
TVA > SOCO	93/109 (2504/47)	**137/94** (545/45)	59.56/46.3 (17.90/48.88)	0/0	0/0	7967/37	0/182	0/58	0	0/6	0/818	0/16
SOCO > MISO	942/254 (3396/22)	53/21 (228/2)	5.33/7.64 (6.31/11)	**683/0**	**347/0**	233/207	**608/890**	**287/573**	**193**	0/4	0/190	0/8
MISO > SOCO	9/275 (2826/48)	102/130 (1264/1264)	**91.89/32.1 (30.91/96.3)**	0/0	0/0	**8440/1506**	0/0	0/0	0	0/55	0/2522	0/110
SOCO > VACAR	**3121/175 (13900/20)**	79/1 **(2071/159)**	2.46/0.56 (12.97/88.60)	97/0	40/0	9/6	49/55	2/6	0	**0/161**	**0/4939**	**0/261**
VACAR□SOCO	263/3752 (760/1129)	10/8 (169/1)	3.66/0.21 (18.25/0.14)	0/0	0/0	0/0	0/2	0/0	0	0/0	0/0	0/0

Table 5.7-7a: SOCO Interface Summary

Top Limiting Flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
SOCO > TVA	None	0	Widows Creek 500/161 bank flo Browns Ferry-Maury 500kV	8
SOCO > MISO	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	8
SOCO > VACAR	None	0	Person-Halifax 230 kV line l/o Wake-Carson 500 kV	119

Table 5.7-7b: SOCO TLR Top Flowgates

Based on the above summary results the following observations were noted.

1. The SOCO-VACAR interface is the most limiting interface in SOCO based on refused GWh, TLR duration, TLR MWh and TLR count. The MISO-SOCO is the most limiting interface based on Zero ATC count.
2. The SOCO-VACAR interface is the most reserved interface based on confirmed TSR count and reservation GWh.
3. The SOCO-MISO interface is the most loaded interface during RT in SOCO based on U90 (schedule). It should be noted that the scheduled flow reported on this interface is significantly higher than actual flow. Schedules may not always represent actual loads because of the RT configuration of the system as well as the fact that GTL schedules may not be reported.
4. No firm TLRs were called on interfaces to or from SOCO; however, non-firm TLRs were called on almost all interfaces. This means that all overloads were mitigated by either cutting non-firm schedules and/or market re-dispatch. The top limiting TLR flowgate was Person-Halifax 230 kV line l/o Wake-Carson 500 kV on SOCO-VACAR.

SOCO sub-region metrics are summarized below. Table 5.7-7c provides the TLR summary for the SOCO sub-region. Table 5.7-7d provides the most limiting flowgate that limits the SOCO sub-region due to TLR.

SOCO	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV	127

Table 5.7-7c: SOCO TLR Sub-Region Summary

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
SOCO	0/169	0/5141	0/277

Table 5.7-7d: SOCO Top Limiting Flowgate for TLR

No firm TLRs were called on interfaces in the SOCO sub-region; however, non-firm TLRs were called, and the Volunteer - Phipps Bend 500 kV FLO Jefferson - Rockport 765 kV flowgate had the most TLRs called upon it.

5.8 NYISO

5.8.1 Sub-Region Metrics

5.8.1.1 Zero AFC Metrics

For NYISO, there was no zero AFC count for the whole year.

5.8.1.2 Market Metric based on Binding count and RT congestion cost

This study developed Market metrics for NYISO and identified the five most limiting flowgates based on the market binding counts and costs. The results from the Market metrics for the NYISO sub-region are provided in Tables 5.8-1a and Table 5.8-1b. Market flow metrics were not developed as NYISO does not post market flow data.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding Hours for the Year
1	CENTRAL EAST - VC	2520	12.82%
2	GOWANUS 138 GREENWD 138 1	2500	12.72%
3	EGRDNCTY 138 VALLYSTR 138 1	2067	10.52%
4	DUNWODIE 345 SHORE_RD 345 1	1700	08.65%
5	GREENWD 138 VERNON 138 1	1537	07.82%

Table 5.8-1a: Five Most Limiting Binding Constraint in NYISO Sub-Region (By Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)	% of Binding Cost for the Year
1	EGRDNCTY 138 VALLYSTR 138 1	2.2	35.46%
2	PACKARD 230 SAWYER 230 1	2.0	32.82%
3	CENTRAL EAST - VC	1.3	20.83%
4	GOWANUS 138 GREENWD 138 1	0.8	12.69%
5	DUNWODIE 345 SHORE_RD 345 1	0.5	08.66%

Table 5.8-1b: Five Most Limiting Binding Constraint in NYISO Sub-Region (By Cost)

5.8.1.3 TLR Metrics

This study also developed TLR metrics for the NYISO sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

Sub-Region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
NYISO	0	0	0	327	101828	825

Table 5.8-2a: TLR Metrics for the NYISO Sub-Region

Sub-Region	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
NYISO	None	0	0	CENTRAL EAST TIES	441	26600
				ONTARIO-ITC	384	75227

Table 5.8.2b: Top Five Limiting Flowgates (Count-Based) for the NYISO Sub-Region

5.8.2 Interface Metrics

5.8.2.1 Transmission Service Request Metric

The results from the TSR metric for NYISO interfaces are provided in Tables 5.8-3a through 5.8-3d. NYISO does not post reservations on their website, therefore this metric was not created for NYISO originating interfaces. These metrics counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
NYISO > PJM	N/A	N/A	N/A
PJM > NYISO	49	1	2
NYISO > ISONE	N/A	N/A	N/A
ISONE > NYISO	19808	N/A	0

Table 5.8-3a: Firm Confirmed and Refused TSR Count

Interface	Non-Firm Confirmed TSR count	Non-Firm Refused TSR count	% Refusal
NYISO > PJM	N/A	N/A	N/A
PJM > NYISO	5462	172	3.05
NYISO > ISONE	N/A	N/A	N/A
ISONE > NYISO	N/A	N/A	N/A

Table 5.8-3b: Non-Firm Confirmed and Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
NYISO > PJM	N/A	N/A	N/A
PJM > NYISO	21428064	N/A	N/A
NYISO > ISONE	N/A	N/A	N/A
ISONE > NYISO	4037149	N/A	N/A

Table 5.8-3c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
NYISO > PJM	N/A	N/A	N/A
PJM > NYISO	17024774	N/A	N/A
NYISO > ISONE	N/A	N/A	N/A
ISONE > NYISO	N/A	N/A	N/A

Table 5.8-3d: Non-Firm Confirmed and Refused Reservation MWh

5.8.2.2 Transmission Reservation Utilization Metric

As stated above, NYISO does not post reservation data, therefore a reservation metric will not be calculated. The results from the Transmission Service Utilization Metric for NYISO interfaces are provided in Tables 5.8-4a and 5.8-4b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
NYISO > PJM	N/A	N/A
PJM > NYISO	8688	2683
NYISO > ISONE	N/A	N/A
ISONE > NYISO	455	N/A

Table 5.8-4a: TRU75 for Firm Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
NYISO > PJM	N/A	N/A
PJM > NYISO	8688	2357
NYISO > ISONE	N/A	N/A
ISONE > NYISO	298	N/A

Table 5.8-4b: TRU90 for Firm Reservation

5.8.2.3 Zero ATC Metrics

The results from the ATC metric for NYISO interfaces are provided in Table 5.8-5.

Interface	Zero ATC Count: Non-Firm	Zero ATC Count: Firm
NYISO > PJM	15	15
PJM > NYISO	2062	2136
NYISO > ISONE	21	21
ISONE > NYISO	12	12

Table 5.8-5: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.8-1a through 5.8-1d).

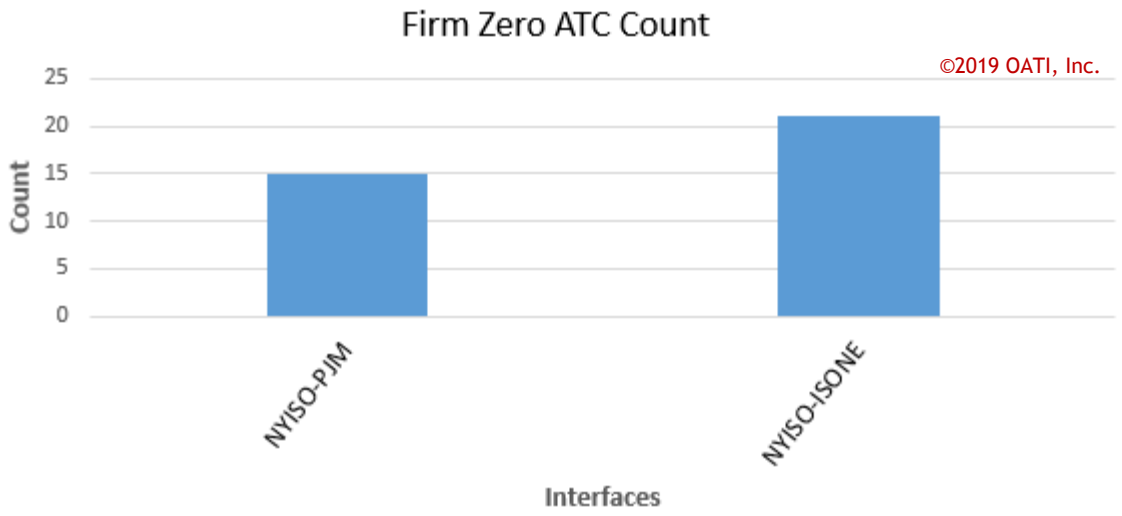


Figure 5.8-1a: Firm Zero ATC Count

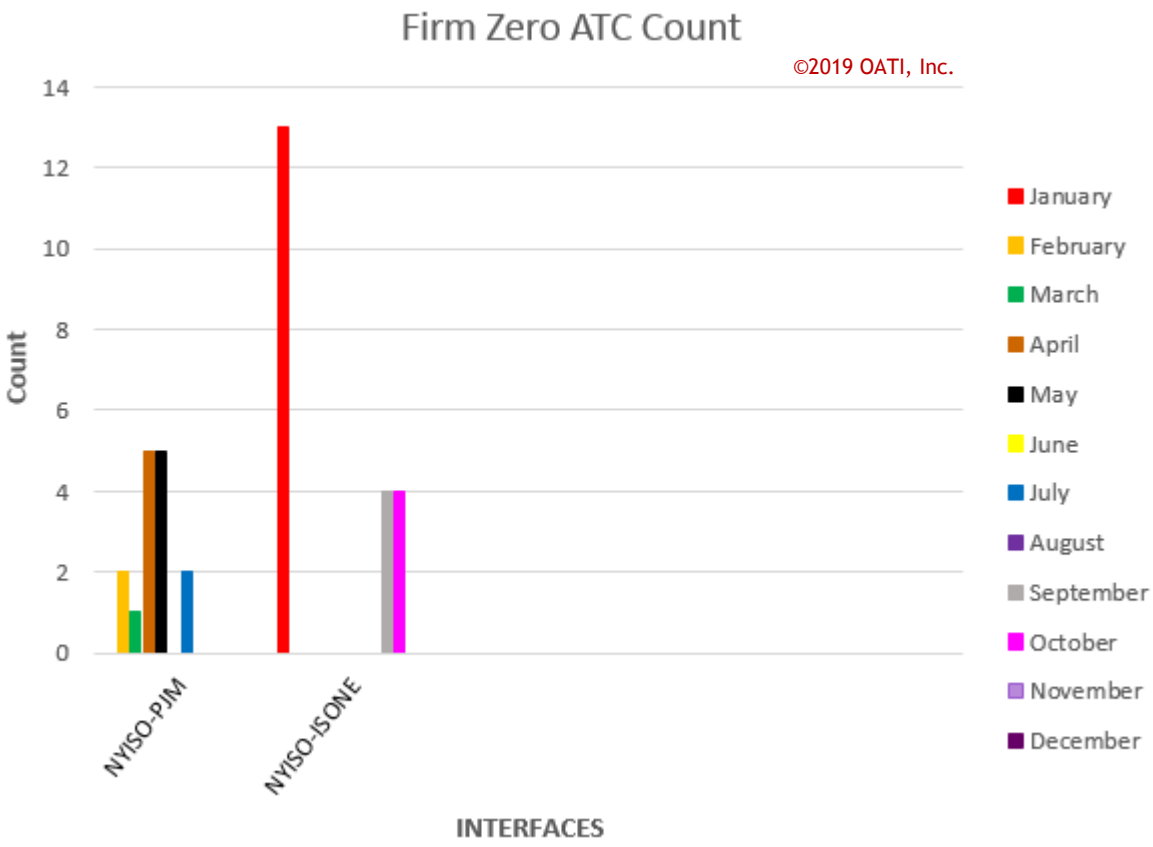


Figure 5.8-1b: Firm Zero ATC Count

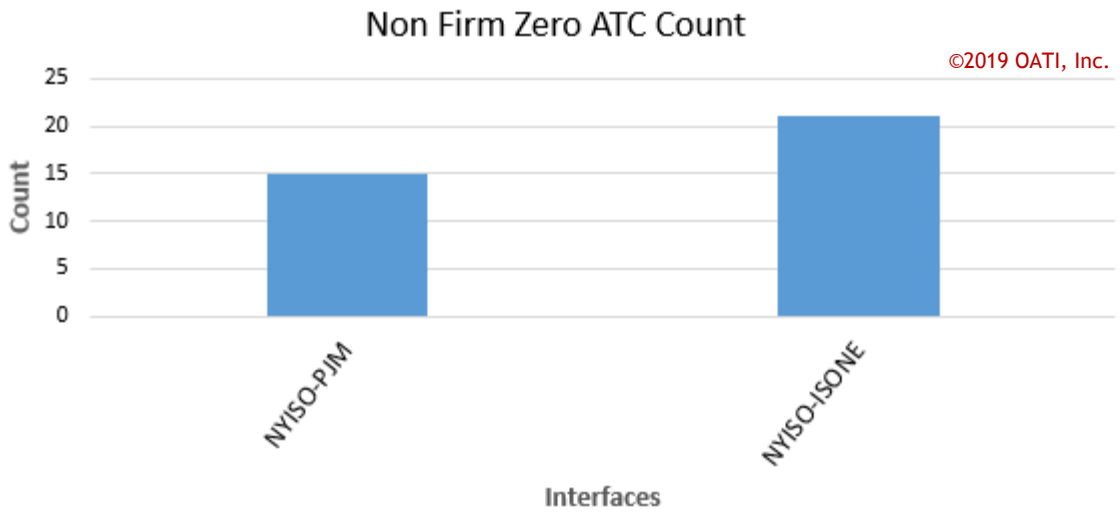


Figure 5.8-1c: Non-Firm Zero ATC Count

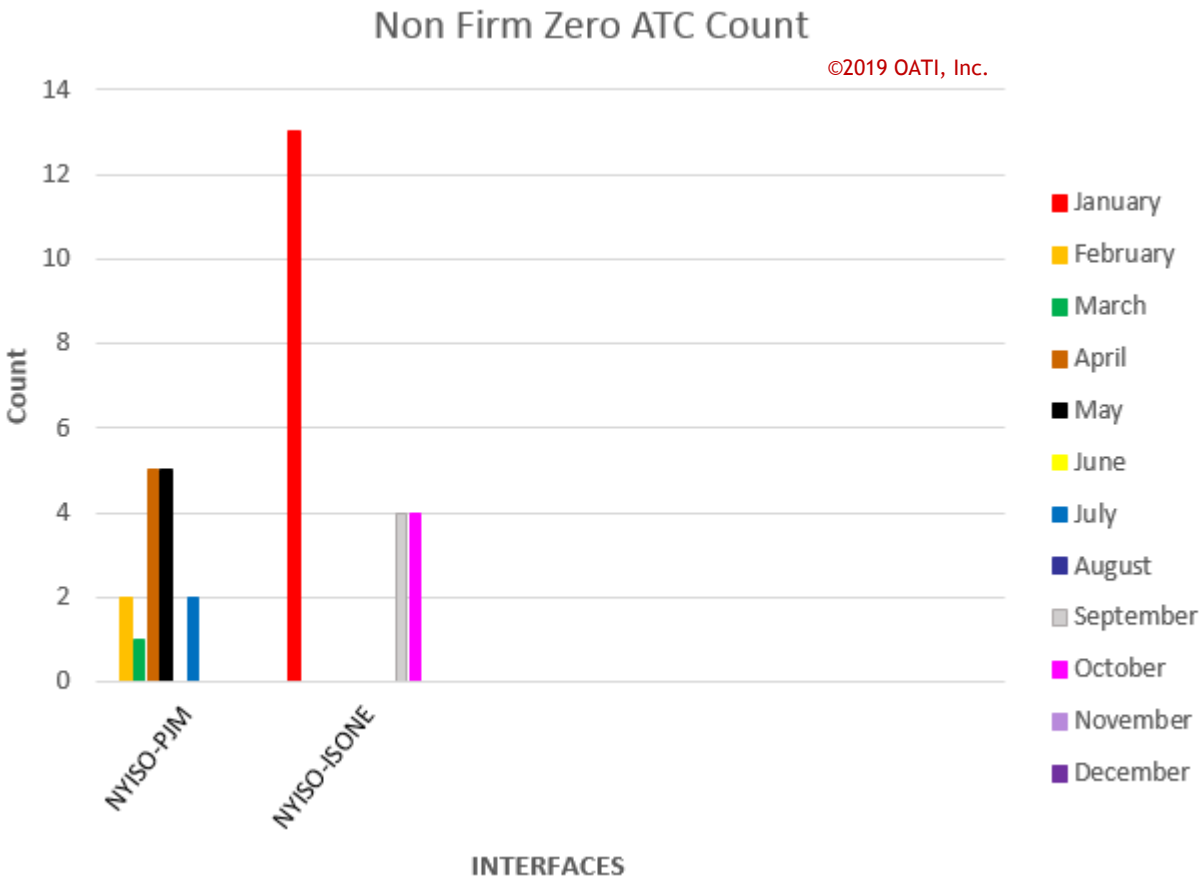


Figure 5.8-1d: Non-Firm Zero ATC Count

5.8.2.4 Schedule Utilization Metrics and Actual Flow Metrics

Schedule utilization metrics and actual flow metrics were calculated for the interfaces. The utilization metric U75 provides a total yearly count for an interface where the hourly scheduled flow exceeds 75 percent of the TTC. The utilization metric U90 provides a total yearly count for an interface where the hourly schedule/flow exceeds 90 percent of the TTC.

The results from the schedule utilization metrics and actual flow metrics for the interfaces are provided in Tables 5.8-6a through 5.8-6d.

Interface	U75 Schedule Count	U90 Schedule Count
NYISO > PJM	85	29
PJM > NYISO	35	4
NYISO > ISONE	0	0
ISONE > NYISO	273	179

Table 5.8-6a: Scheduled flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
NYISO > PJM	0	0
PJM > NYISO	0	0
NYISO > ISONE	0	0
ISONE > NYISO	2155	1233

Table 5.8-6b: Actual Flow Utilization Metric

Metrics for interfaces based on the schedule count above the TTC were also developed. The results for the metrics are provided in Table 5.8-6c.

Interface	Schedule Count above TTC
NYISO > PJM	15
PJM > NYISO	1
NYISO > ISONE	0
ISONE > NYISO	135

Table 5.8-6c: Schedule Count above TTC

5.8.2.5 TLR Metrics

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metric for the interfaces are provided in Table 5.8-7a and Table 5.8-7b.

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
NYISO > PJM	0	0	0	160	75227	384
PJM > NYISO	0	0	0	0	0	0
NYISO > ISONE	0	0	0	168	26600	441
ISONE > NYISO	0	0	0	0	0	0

Table 5.8-7a: TLR Metrics for NYISO Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
NYISO > PJM	None	0	0	ONTARIO-ITC	384	75227
NYISO > ISONE	None	0	0	CENTRAL EAST TIES	441	26600

Table 5.8-7b: Top Five Limiting Flowgates (Count-Based) for NYISO Interfaces

5.8.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all of the study interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

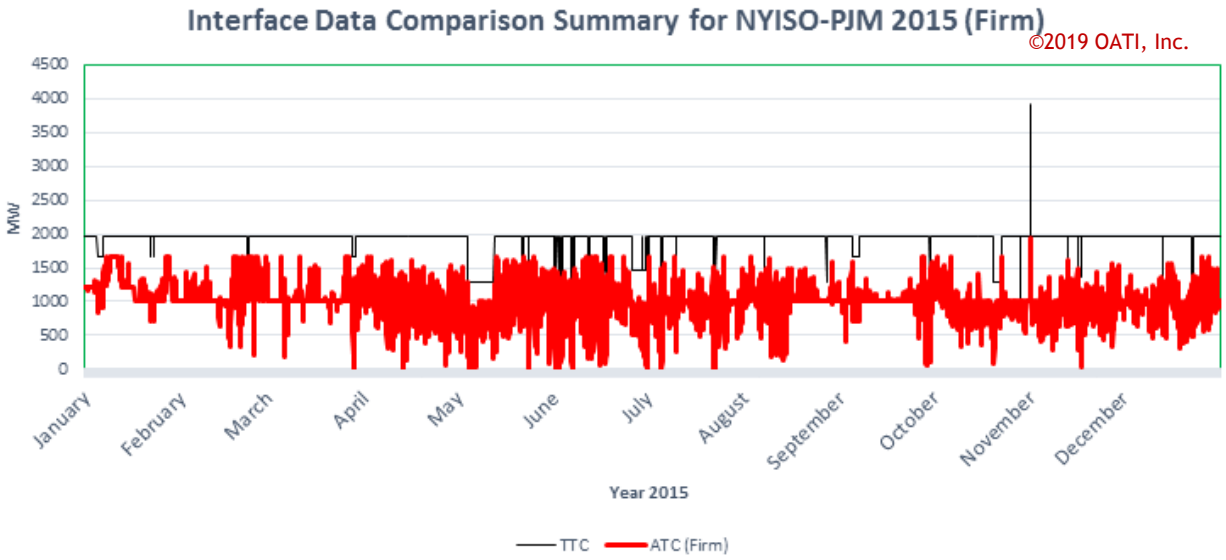


Figure 5.8-2a: Interface Firm ATC and Reservation Comparison Summary for NYISO > PJM 2015

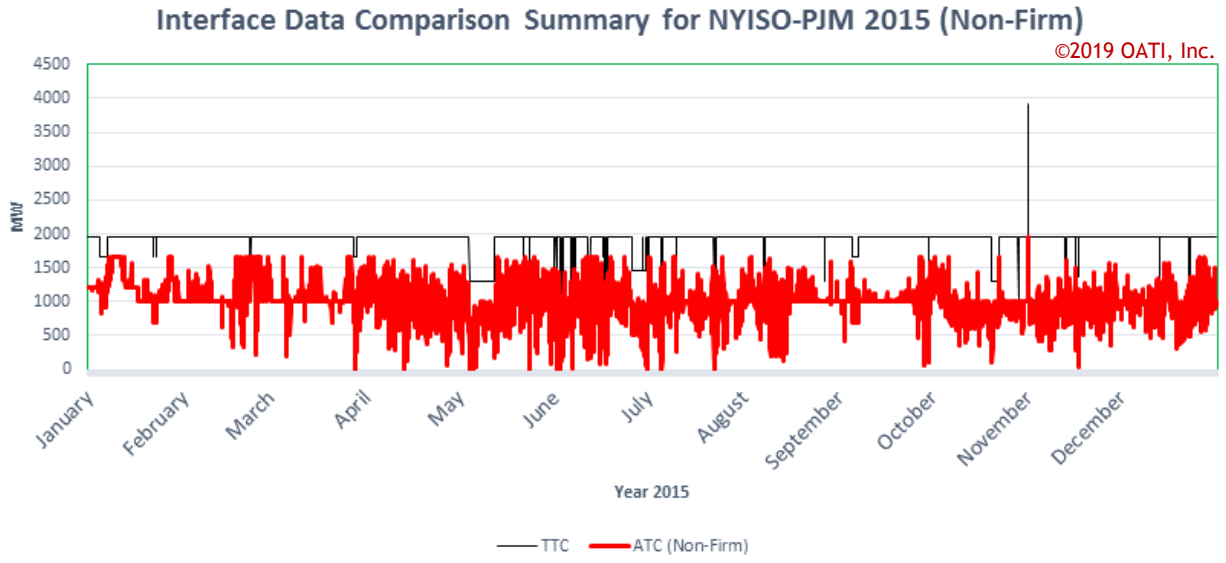


Figure 5.8-2b: Interface Non-Firm ATC and Reservation Comparison Summary for NYISO > PJM 2015

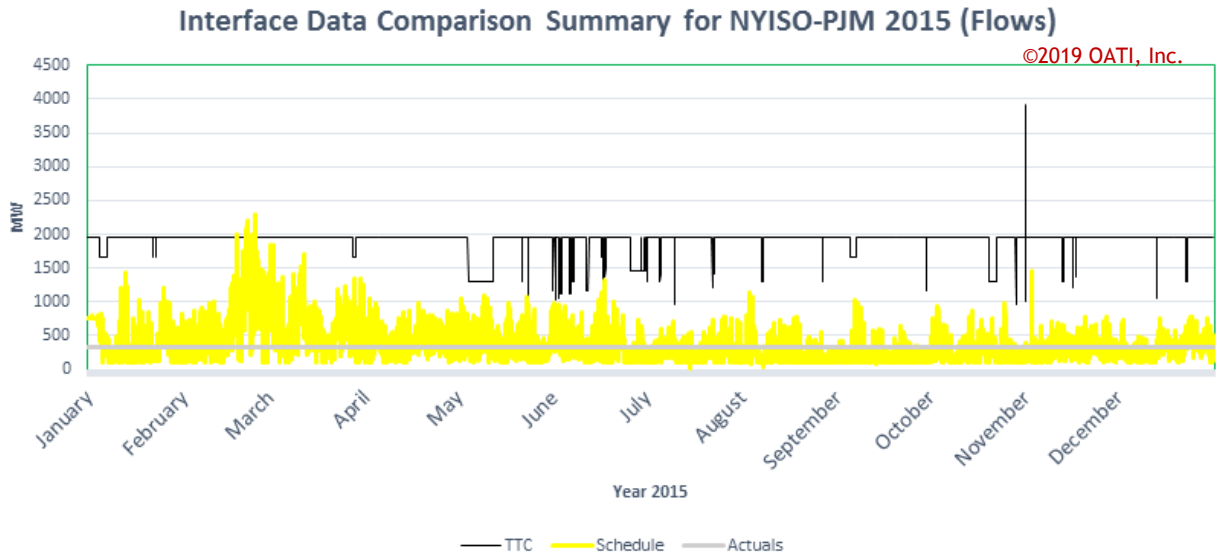


Figure 5.8-2c: Interface Flow Comparison Summary for NYISO > PJM 2015

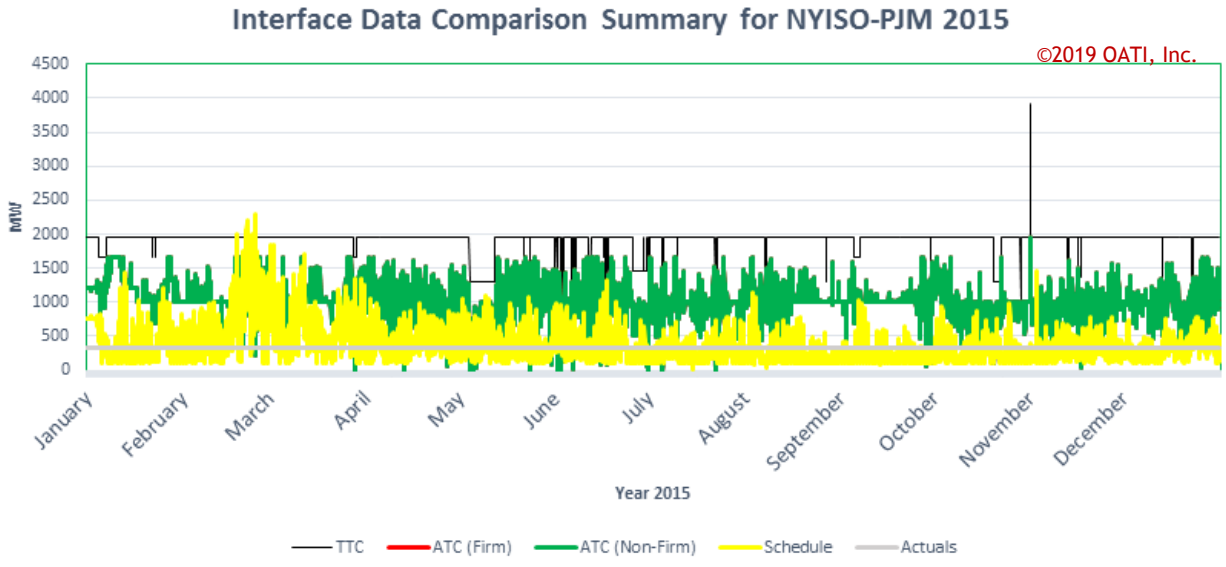


Figure 5.8-2d: Interface Comparison Summary for NYISO > PJM 2015

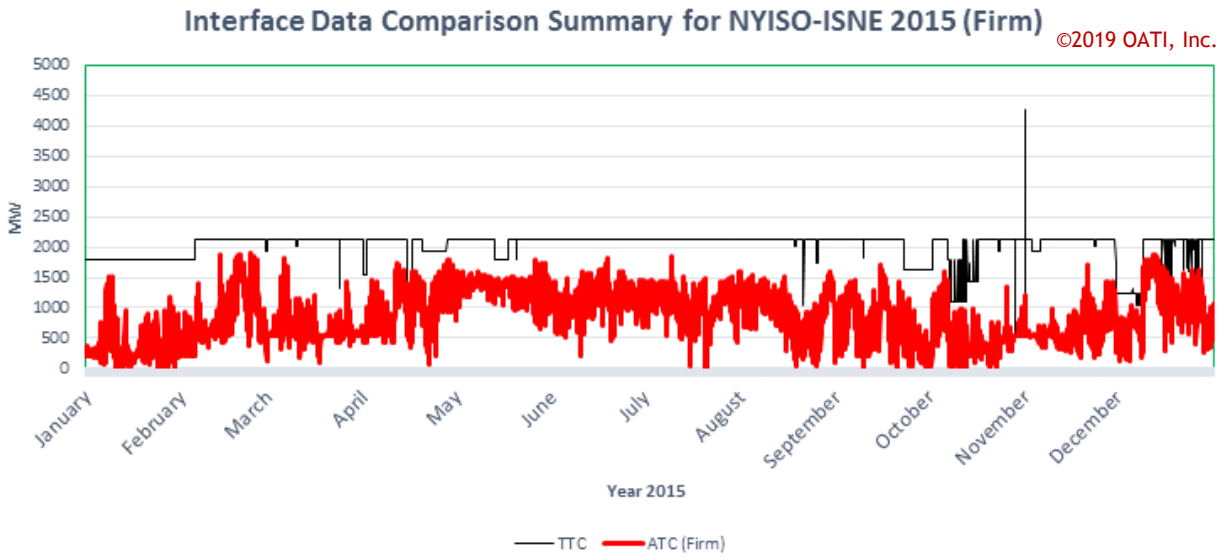


Figure 5.8-2e: Interface Firm ATC and Reservation Comparison Summary for NYISO > ISNE 2015

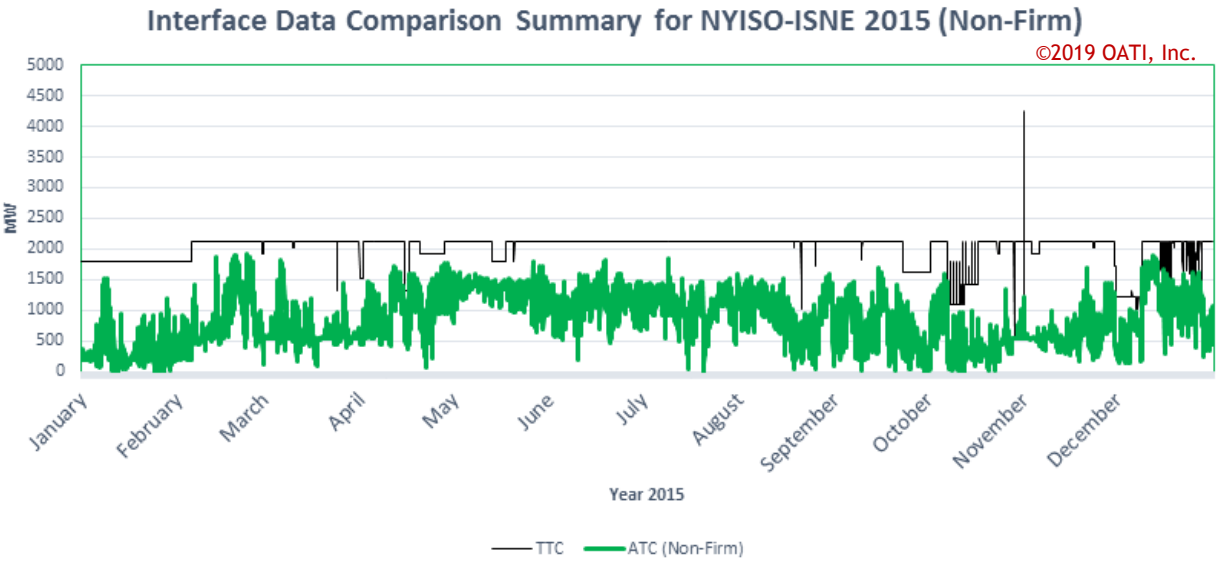


Figure 5.8-2f: Interface Non-Firm ATC and Reservation Comparison Summary for NYISO > ISNE 2015

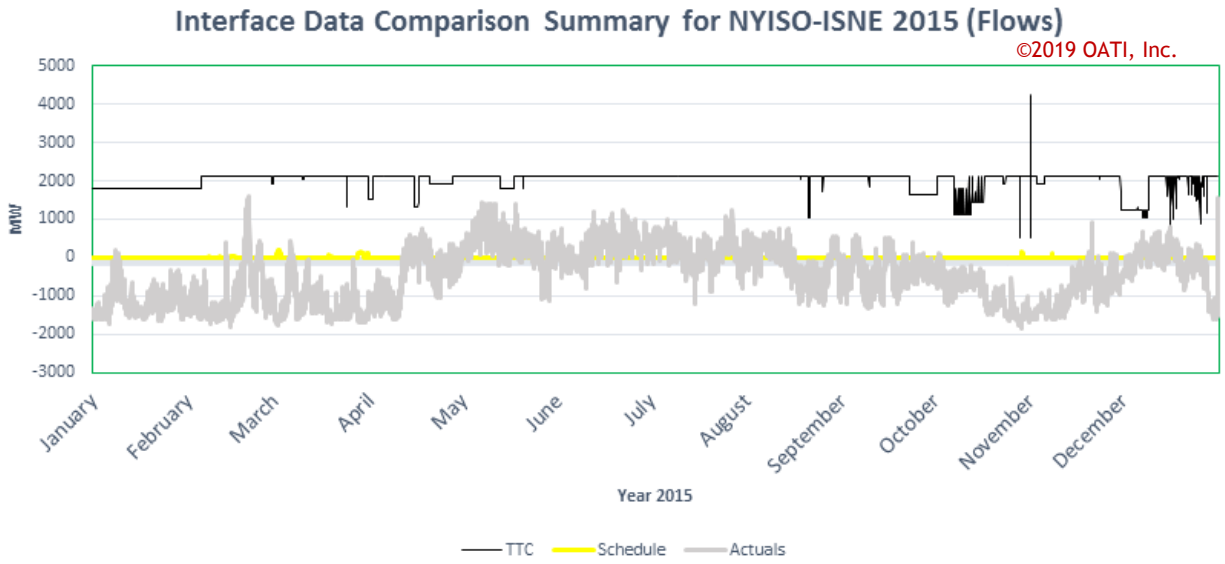


Figure 5.8-2g: Interface Flow Comparison Summary for NYISO > ISNE 2015

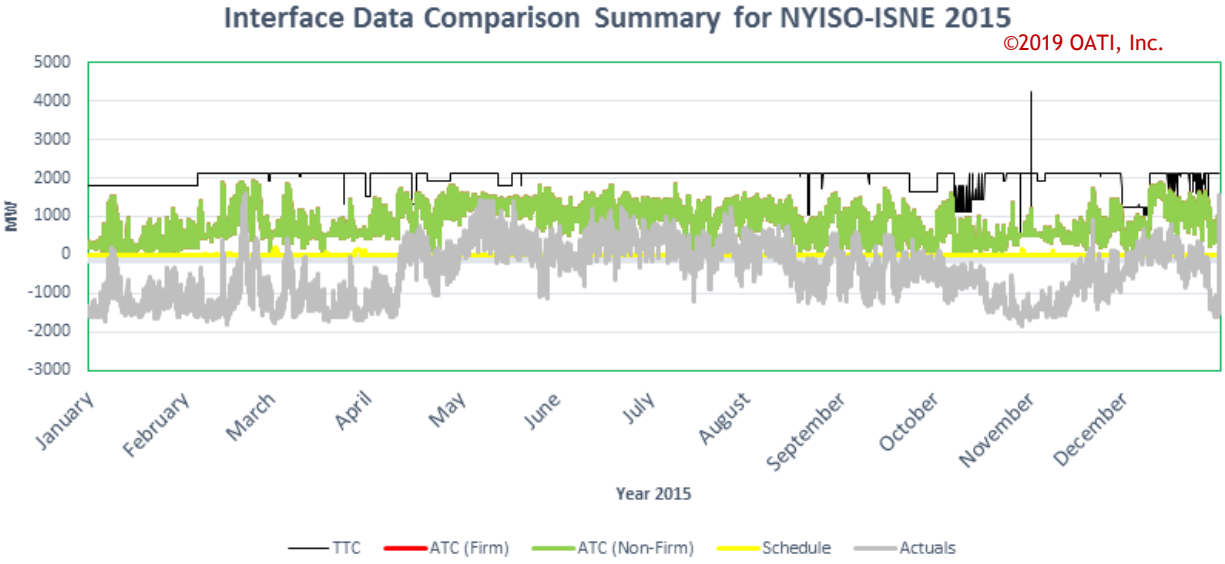


Figure 5.8-2h: Interface Comparison Summary for NYISO > ISNE 2015

5.8.4 NYISO Study Metrics Summary

Both metrics for the NYISO sub-region and its interfaces between NYISO and neighboring sub-regions are summarized in this section along with the study findings. Table 5.8-8a provides the interface summary related to NYISO to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below

represent the highest metric values among all the interfaces between NYISO and other sub-regions. The top limiting flowgate for each interface due to zero ATC and TLR is also summarized in Table 5.8-8b, also highlighted flowgate in Table 5.8-8b represents the most limiting flowgate that limits PJM interfaces due to TLR.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule/ Actual Yearly Count	U90 Schedule/ Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
NYISO > PJM	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A	N/A	15/15	85/0	29/0	15	0/160	0/75227	0/384
PJM > NYISO	49/5462 (21428/17024)	1/172 (N/A)	2/3.05 (N/A)	8688/2683	8688/2357	2136/2062	35/0	4/0	1	0/0	0/0	0/0
NYISO > ISONE	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A	N/A	21/21	0/0	0/0	0	0/168	0/26600	0/441
ISONE > NYISO	19808/0 (4037/NA)	0/0 (N/A)	0/0 (N/A)	455/NA	298/NA	12/12	273/2155	179/1233	135	0/0	0/0	0/0

Table 5.8-8a: NYISO Interface Summary

Top Limiting flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
NYISO > PJM	None	0	ONTARIO-ITC	384
NYISO > ISONE	None	0	CENTRAL EAST TIES	441

Table 5.8-8b: NYISO TLR Top Flowgates

Based on the above summary results, the following observations are noted.

1. The NYISO-PJM interface is the most limiting based on non-firm TLR MWh. The PJM- NYISO is the most limiting interface based on zero ATC count, refused TSR count and percentage refusal.
2. PJM-NYISO interface is the most reserved interface in NYISO based on confirmed reservation GWh, TRU75 and TRU90 count.
3. The ISONE-NYISO interface is the most loaded interface during RT in NYISO based on U90 (schedule). It should be noted that the schedule reported on this interface is significantly lower than actual flow. Schedules may not always represent actual load because of the RT configuration of the system as well as generation to load schedules may not be reported.
4. No firm TLRs were called on Interfaces to or from NYISO; however, non-firm TLRs were called on both interfaces going out of NYISO. Top limiting TLR flowgate is CENTRAL EAST TIES.

NYISO sub-region metrics are summarized below. Table 5.8-8c provides TLR summary for NYISO sub-region. Table 5. 8-8d provides the most limiting flowgate that limits NYISO sub region due to TLR. Table 5.8-8e provide the most limiting binding constraint that limits the NYISO sub-region during the RT market.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
NYISO	0/327	0/101828	0/825

Table 5.8-8c: - NYISO TLR Sub-Region Summary

NYISO	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	CENTRAL EAST TIES	441

Table 5.8-8d: NYISO Top Limiting Flowgate for TLR

NYISO	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour count	Binding Constraints Name	Congestion cost
Top Binding Constraint	CENTRAL EAST - VC	2520	EGRDNCTY 138 VALLYSTR 138 1	$2.2 M

Table 5.8-8e: Most Limiting Binding Constraint in NYISO market

1. No firm TLRs were called on interfaces in the NYISO sub-region; however, non-firm TLRs were called on CENTRAL EAST TIES which was the top limiting flowgate.
2. In the NYISO market, the most limiting binding constraint was CENTRAL EAST – VC.
3. A separate comparison was performed which is included in Appendix D based on the DOE's *Annual U.S. Transmission Data Review* that publishes a list of top constraints observed in the NYISO sub-region. In comparing both results, there are some consistencies between the 2016 U.S. Transmission Data Review and this study, these constraints (CENTRAL EAST - VC, GOWANUS 138 GREENWD 138 1 and EGRDNCTY 138 VALLYSTR 138 1) do show up in both the results.

5.9 ISONE

5.9.1 Sub-Region Metrics

5.9.1.1 Market Metric based on the Binding count and RT Congestion Cost

This study developed market metrics for ISONE and identified the five most limiting flowgates based on the congestion cost. Market flow metrics were not developed as ISONE does not post market flow data.

For market data, ISONE provided 5-minute data. The constraint marginal value provided was in $/MWh. The study used 5-minute data which were converted to hourly data, and congestion cost was calculated as a multiplication of flow and marginal value. An example calculation is provided below for quick reference.

Date/Time	Constraint Name	RT Value/ RT Flow	RT Marginal Value	Hourly MV=MV/12*	Congestion Cost ($)
1/5/2015 4:30	BASE_INTRFC_BRAY12	306.3	-16.47	-1.37	-420
1/5/2015 4:35	BASE_INTRFC_BRAY12	303.8	-17.49	-1.45	-442
1/5/2015 4:40	BASE_INTRFC_BRAY12	303.0	-16.53	-1.37	-417
1/5/2015 4:45	BASE_INTRFC_BRAY12	305.8	-16.54	-1.37	-421
1/5/2015 4:50	BASE_INTRFC_BRAY12	305.6	-16.50	-1.37	-420
1/5/2015 4:55	BASE_INTRFC_BRAY12	304.4	-16.62	-1.38	-421
			Total Congestion Cost	* Hour is divided into 12 5-minute intervals	**-2543**

Table 5.9-1: Congestion Cost Calculation Example

The results from the Market metrics for the ISONE sub-region are provided in Tables 5.9-1a and 5. 9-1b.

Binding Constraints Ranking	Binding Constraints Name	Market Binding Hour Count	% of Binding hours
1	326_SEABROOK_394-1_A	135	11.44%
2	BASE_INTRFC_BERK	125	10.59%
3	BASE_HAWKINS_250-517-3_A	122	10.34%
4	BASE_INTRFC_ORR-SO	90	7.63%
5	BASE_INTRFC_LRD1	77	6.53%

Table 5.9-1a: Five Most Limiting Binding Constraint in the ISONE Sub-Region (By Count)

Binding Constraints Ranking	Binding Constraints Name	Congestion Cost ($M)	% Congestion Cost
1	326_SEABROOK_394-1_A	10.5	38.75%
2	319_KNGSTN_S_345B_345B	3.60	13.14%
3	BASE_INTRFC_SBRK_S	3.10	11.33%
4	BASE_INTRFC_ORR-SO	1.90	06.88%
5	BASE_HAWKINS_250-516-3_A	1.10	03.99%

Table 5.9-1b: Five Most Limiting Binding Constraint in the ISONE Sub-Region (By Cost)

5.9.1.2 TLR Metrics

This study also developed TLR metrics for the ISONE sub-region and identified the five most limiting TLR flowgates based on the TLR counts.

Sub-region	Firm			Non-Firm		
	TLR Duration (Hours)	TLR MWh	TLR Count	TLR Duration (Hours)	TLR MWh	TLR Count
ISONE	0	0	0	0	0	0

Table 5.9-2: TLR metrics for the ISONE Sub-Region

5.9.2 Interface Metrics

5.9.2.1 Transmission Service Request Metric

The results from the TSR metric for ISONE interfaces are provided in Tables 5.9-3a through 5.9-3d. This metric counted the total number of firm and non-firm TSRs that were either confirmed or refused on the interfaces.

Interface	Firm Confirmed TSR Count	Firm Refused TSR Count	% Refusal
ISONE > NYISO	19808	0	0
NYISO > ISONE	N/A	N/A	N/A

Table 5.9-3a: Firm Confirmed and Refused TSR Count

Interface	Non-Firm Confirmed TSR Count	Non-Firm Refused TSR Count	% Refusal
ISONE > NYISO	0	0	0
NYISO > ISONE	N/A	N/A	N/A

Table 5.9-3b: Non-Firm Confirmed and Refused TSR count

Interface	Firm Confirmed Reservation MWh	Firm Refused Reservation MWh	% Refusal
ISONE > NYISO	4037149	N/A	N/A
NYISO > ISONE	N/A	N/A	N/A

Table 5.9-3c: Firm Confirmed and Refused Reservation MWh

Interface	Non-Firm Confirmed Reservation MWh	Non-Firm Refused Reservation MWh	% Refusal
ISONE > NYISO	N/A	N/A	N/A
NYISO > ISONE	N/A	N/A	N/A

Table 5.9-3d: Non-Firm Confirmed and Refused Reservation MWh

5.9.2.2 Transmission Reservation Utilization Metric

In discussions with ISONE, it was pointed out that there are significant differences in the ISONE markets. There is no requirement for any customer to purchase transmission service on their system prior to submitting transactions to the ISONE RT market. The reservations are created on OASIS by ISONE after-the-fact based on what was economically scheduled by the ISONE RT market. ISONE does not require any prior transmission reservations to schedule energy. Therefore, the study did not calculate any TSR metric.

The ISONE RT market is scheduled on an hourly basis on all interfaces except the NYN AC interface, which is also known at the Coordinated Transaction Scheduling interface. On the Coordinated Transaction Scheduling interface, scheduling is done on a 15-minute basis. On the hourly interfaces, the reservation and the schedules are nearly always the same. On the Coordinated Transaction Scheduling interface, the reservation is created based on the highest MW value that was scheduled over the hour, and the schedule against that reservation is the integrated schedule over the hour.

The results from the Transmission Service Utilization Metric for the ISONE interfaces are provided in Tables 5.9-4a and 5.9-4b.

Interface	TRU75 Count: Firm	TRU75 Count: Non-Firm
ISONE > NYISO	455	0
NYISO > ISONE	N/A	N/A

Table 5.9-4a: TRU75 for Reservation

Interface	TRU90 Count: Firm	TRU90 Count: Non-Firm
ISONE > NYISO	298	0
NYISO > ISONE	N/A	N/A

Table 5.9-4b: TRU90 for Reservation

5.9.2.3 Zero ATC Metrics

The results from the ATC metric for ISONE interfaces are provided in Table 5.9-5.

Interface	Zero ATC Count: Non-Firm	Zero ATC Count: Firm
ISONE > NYISO	12	12
NYISO > ISONE	21	21

Table 5.9-5: Zero ATC Count

The study also developed additional zero ATC graphs for visualizing and comparing ATC metrics between the interfaces (see Figures 5.9-1a through 5.9-1d).

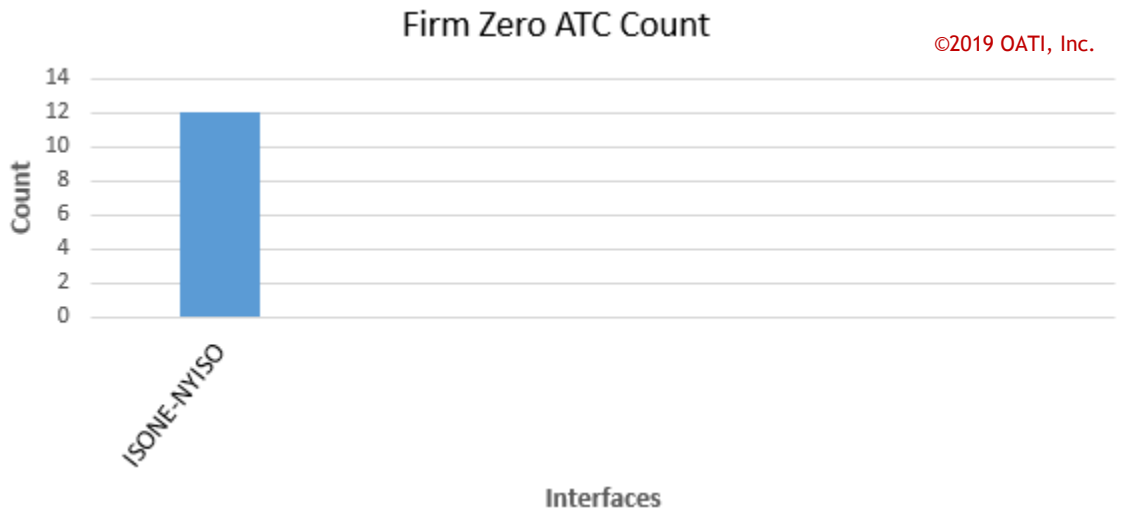


Figure 5.9-1a: Firm Zero ATC Count

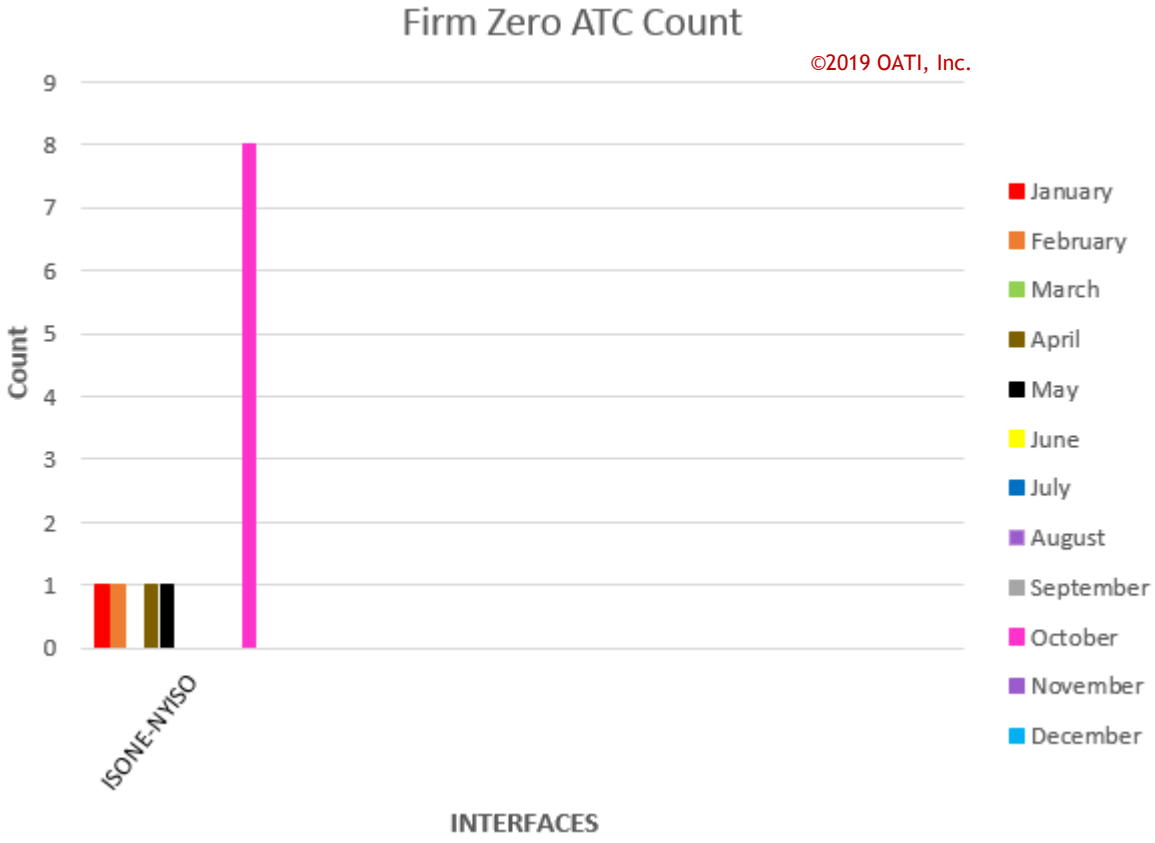


Figure 5.9-1b: Firm Zero ATC Count

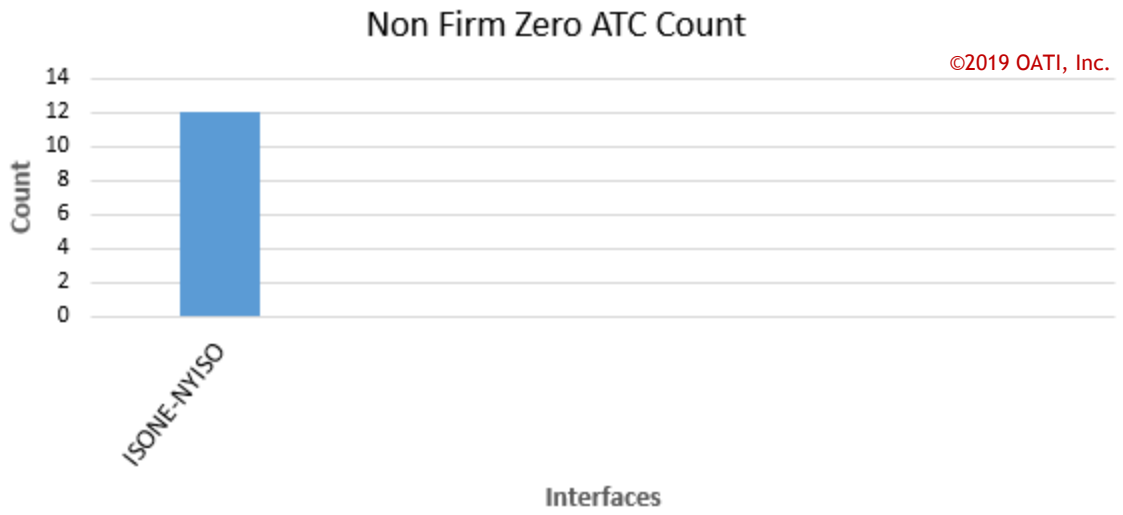


Figure 5.9-1c: Non-Firm Zero ATC Count

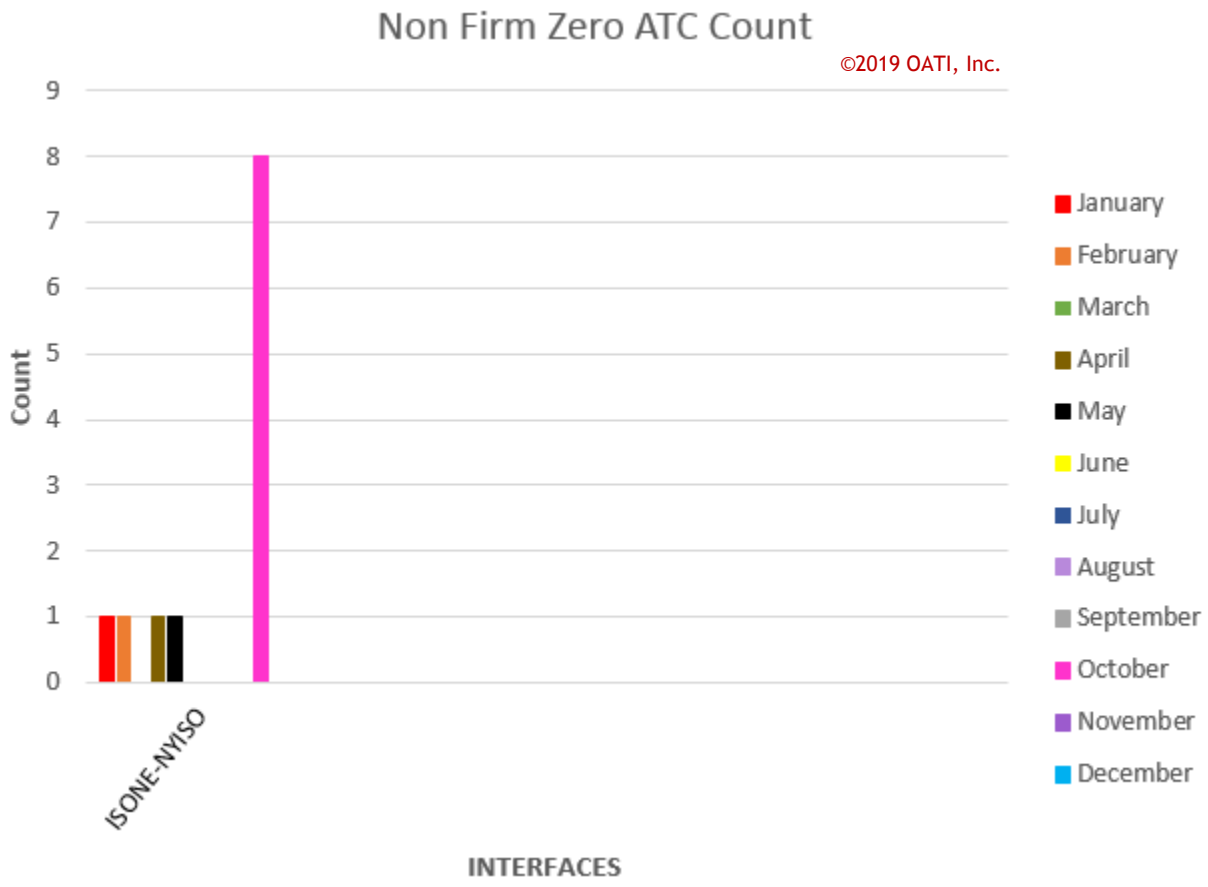


Figure 5.9-1d: Non-Firm Zero ATC Count

5.9.2.4 Schedule Utilization Metrics and Actual Flow Metrics

Schedule utilization metrics and actual flow metrics were calculated for the interfaces. The utilization metric U75 provides the total yearly count for an interface where the hourly scheduled flow exceeds 75 percent of the TTC. The utilization metric U90 provides the total yearly count for an interface where the hourly schedule/flow exceeds 90 percent of the TTC.

The results from schedule utilization metrics and actual flow metrics for the interfaces are provided in Tables 5.9-6a through 5.9-6d.

Interface	U75 Schedule Count	U90 Schedule Count
ISONE > NYISO	273	179
NYISO > ISONE	0	0

Table 5.9-6a: Scheduled Flow Utilization Metric

Interface	U75 Actual Count	U90 Actual Count
ISONE > NYISO	2155	1233
NYISO > ISONE	0	0

Table 5.9-6b: Actual Flow Utilization Metric

A metric for interfaces based on a schedule count above the TTC was also developed. The results for the metric are provided in Table 5.9-6c.

Interface	Schedule Count above TTC
ISONE > NYISO	135
NYISO > ISONE	21

Table 5.9-6c: Schedule Count above TTC

5.9.2.5 TLR Metric

The five most limiting flowgates were identified based on the TLR counts. The results from the TLR metric for the interfaces are provided in Tables 5.9-7a and 5.9-7b.

Interface	Firm			Non-Firm		
	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count	Yearly TLR Duration (Hours)	Yearly TLR MWh	Yearly TLR Count
ISONE > NYISO	0	0	0	0	0	0
NYISO > ISONE	0	0	0	168	26600	441

Table 5.9-7a: TLR Metrics for Interfaces

Interface	Firm			Non-Firm		
	Flowgate	Count	MWh	Flowgate	Count	MWh
ISONE > NYISO	None	0	0	None	0	0

Table 5.9-7b: Top Five Limiting Flowgates (Count Based) for ISONE Interfaces

5.9.3 Interface Data Analysis Summary

The following graphs compare data such as TTC, ATC, reservation, and actual and scheduled flow for the whole year for all study interfaces. Each interface graphed below has four graphs. The first graph plots non-firm ATC, non-firm reservation, and TTC. The second graph plots firm ATC, firm reservation, and TTC. The third graph plots actual flow, scheduled flow, and TTC. The fourth graph is a combination of all the parameters.

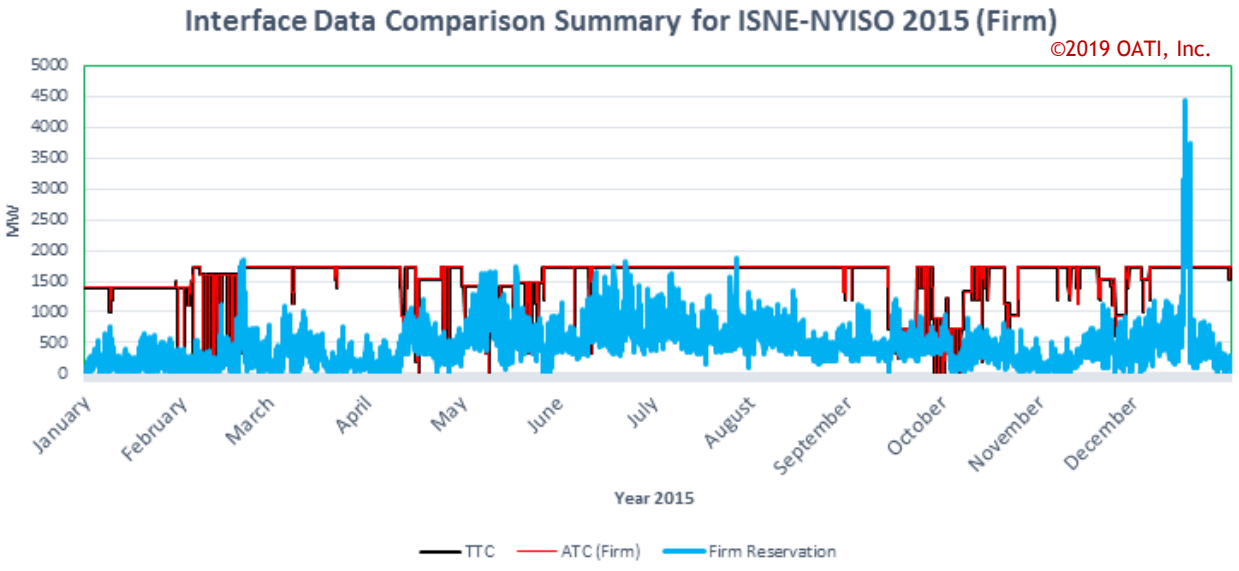


Figure 5.9-2a: Interface Firm OASIS Comparison Summary for ISONE > NYISO 2015

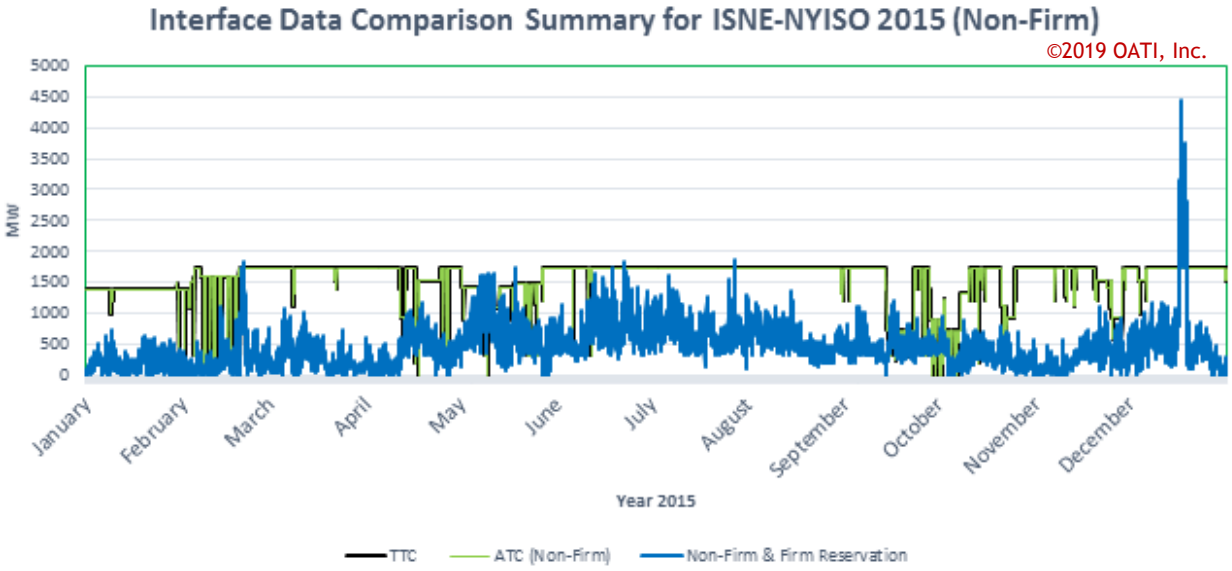


Figure 5.9-2b: Interface Non-Firm OASIS Comparison Summary for ISONE > NYISO 2015

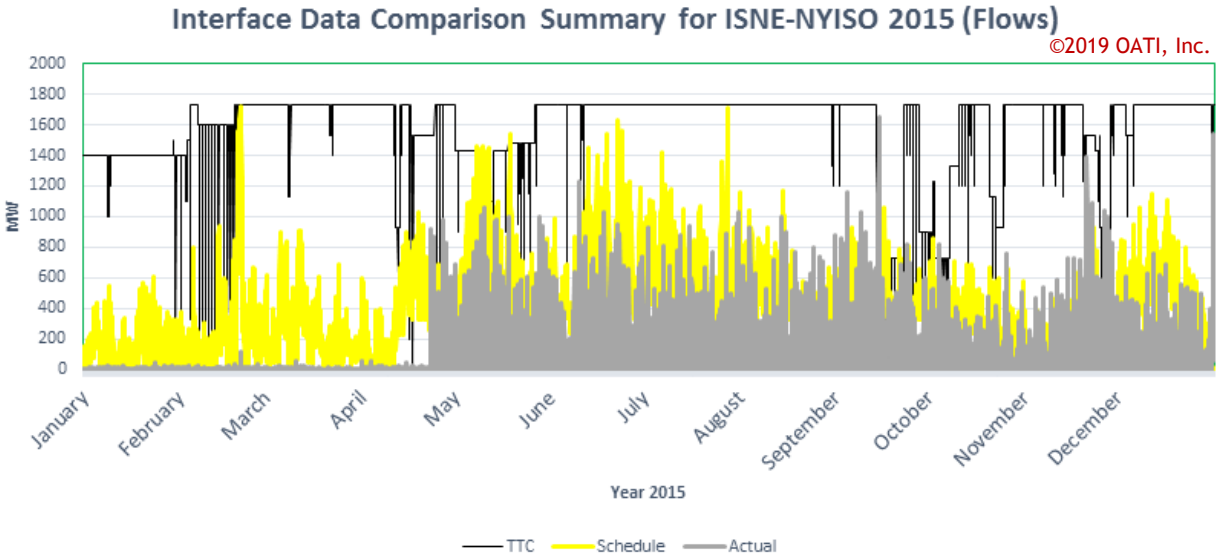


Figure 5.9-2c: Interface Flow Comparison Summary for ISONE > NYISO 2015

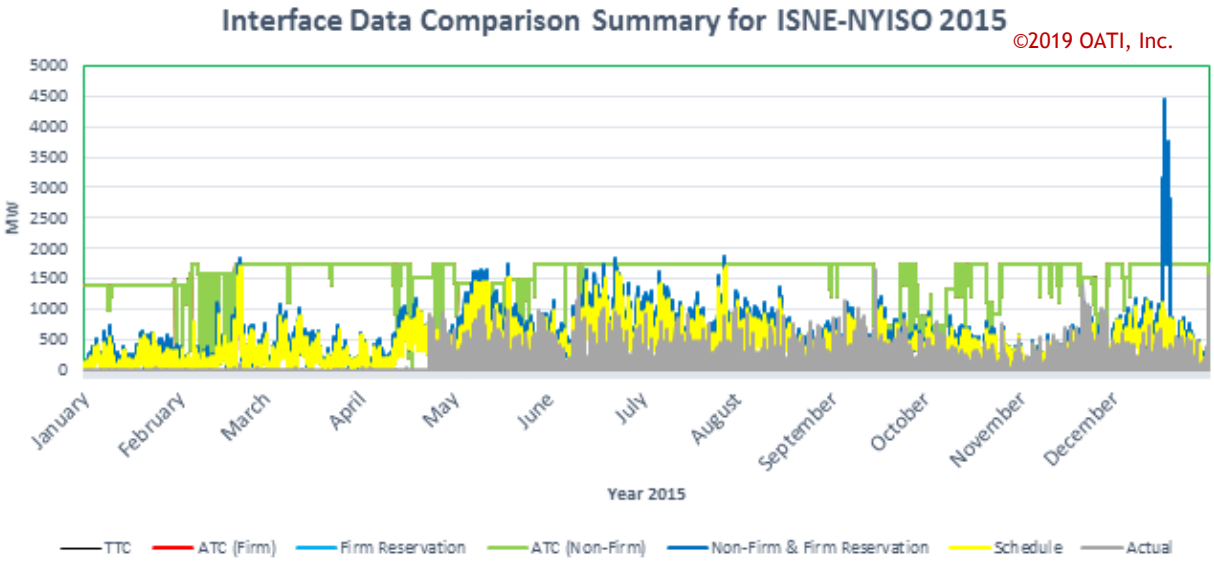


Figure 5.9-2d: Interface Comparison Summary for ISONE > NYISO 2015

5.9.4 ISONE Study Metrics Summary

Both metrics for the ISONE sub-region and its interfaces between ISONE and neighboring sub-regions are summarized in this section along with the study findings. Table 5.9-8a provides the interface summary related to ISONE to visualize and compare its performance or limitations during reservations, scheduling, and RT operation. The highlighted values in the tables below represent the highest metric values among all the interfaces between ISONE and other sub-regions. The top limiting flowgate for each interfaces due to zero ATC and TLR is also summarized in Table 5.9-8b. The highlighted flowgate in Table 5.9-8b represents the most limiting flowgate that limits ISONE interfaces due to TLR.

Interface	Confirmed TSR Count (Reservation GWh): Firm/Non-Firm	Refused TSR Count (Reservation GWh): Firm/Non-Firm	% Refusal TSR Count (Reservation GWh): Firm/Non-Firm	TRU75 Yearly Count: Firm/Non-Firm	TRU90 Yearly Count: Firm/Non-Firm	Zero ATC Yearly Count: Firm/Non-Firm	U75 Schedule/ Actual Yearly Count	U90 Schedule/ Actual Yearly Count	Yearly Schedule Count above TTC	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
ISONE > NYISO	19808/0 (4037/NA)	0/0 (N/A)	0/0 (N/A)	455/0	298/0	12/12	273/2155	179/1233	135	0/0	0/0	0/0
NYISO > ISONE	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A	N/A	21/21	0/0	0/0	21	0/168	0/26600	0/441

Table 5.9-8a: ISONE Interface Summary

Top limiting flowgate	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
NYISO > ISONE	None	0	CENTRAL EAST TIES	441
ISONE > NYISO	None	0	None	0

Table 5.9-8b: ISONE TLR Top Flowgates

Based on the above summary results, the following observations are noted.

1. The NYISO –ISONE is the most limiting interface based on TLR duration, MWh and count.
2. The ISONE-NYISO interface is the most reserved interface in ISONE based on confirmed TSR count, confirmed reservation GWh, TRU 75 and TRU90 count.
3. The ISONE-NYISO interface is the most loaded interface during RT operation in ISONE. It should be noted that the schedule reported on this interface is significantly higher than actual flow. Schedules may not always represent the actual load because of the RT configuration of the system, as well as the fact that FTL schedules may not be reported.
4. No firm TLRs were called on interfaces to or from ISONE; however, non-firm TLRs were called on the interface going into ISONE. The top limiting TLR flowgate was CENTRAL EAST TIES on NYISO-ISONE.

The ISONE sub-region metrics are summarized below. Table 5.9-8c provides the TLR summary for the ISONE sub-region. Table 5.9-8d provides the most limiting flowgate that limits the ISONE sub-region due to TLR.

Sub-Region	Yearly TLR Duration: Firm/Non-Firm (Hours)	Yearly TLR MWh: Firm/Non-Firm	Yearly TLR Count: Firm/Non-Firm
ISONE	0/0	0/0	0/0

Table 5.9-8c: ISONE TLR Sub-Region Summary

ISONE	Firm TLR		Non-Firm TLR	
	Flowgate	Count	Flowgate	Count
Top limiting flowgate	None	0	None	0

Table 5.9-8d: ISONE top limiting flowgate for TLR

ISONE	Constraint due to Count		Constraint due to Cost	
	Binding Constraints Name	Market Binding Hour Count	Binding Constraints Name	Congestion Cost
Top Binding Constraint	326_SEABROOK_394-1_A	135	326_SEABROOK_394-1_A	$10.5 M

Table 5.9-8e: Most Limiting Binding Constraint in ISONE Market

1. No firm or non-firm TLRs were called on interfaces in the ISONE sub-region.
2. In the ISONE market, the most limiting binding constraint is 326_SEABROOK_394-1_A.

3. A separate comparison was performed which was included in Appendix D based on the DOE's *Annual U.S. Transmission Data Review* that publishes a list of top constraints observed in the ISONE sub-region which listed SEMA/RI and NEMA/Boston capacity zones as the areas constrained. Both results show that there are some consistencies between the 2016 U.S. Transmission Data Review and this study results such as Flowgate 326_SEABROOK_394-1_A in NEMA/Boston area and B202_TEWKSBRY_O215_A in the Boston area.

6. Summary

This congestion study used a number of sets of data: metrics based on OASIS data, webTag data, actual Real Time flow data, market data, and IDC data, to analyze congestion in the Eastern Interconnection from the year 2015.

These three sets of data are complementary, but may not necessarily reinforce each other. This is because some are related to the planning perspective of congestion patterns (e.g., long-term OASIS transmission reservations), some to commercial commitments (e.g., bilateral schedules and up-to-congestion bids), and others relate to actual congestion patterns (e.g., IDC actions and RT congestion).

Congestion metrics were developed through the study methodology for these three sets of data. All metric calculations used hourly data as the basic input. Some metrics represent the yearly count of a specific occurrence. For example, the zero ATC metrics provide a yearly count of the hours where an interface is fully subscribed or the ATC is equal to or less than zero. The study also identified the top five limiting flowgates due to ATC limitations, TLR calls, and market congestion. The study also captured historical transmission system limitations starting from the time of making reservations to transfer energy to RT scheduling and operation by using data available from each stage of the energy transfer process.

The following are the metrics developed as part of this study:

- Yearly TSR Count.
- Yearly TRU.
- Yearly Zero ATC Count.
- Yearly Zero AFC Count for PJM and top five limiting flowgate.
- Yearly Schedule Utilization and Actual flow count.
- Yearly TLR Count and MWH Curtailed.
- Top Five Most Limiting Flowgates for an interface due to zero ATC and TLR calls.
- Top Five Most Limiting Flowgates for a Sub-region due to TLR calls.
- Market Metric based on Binding count and RT congestion cost.
- Market flow metric based on Binding count and market flow settlement cost.

The data was either provided or permission was given for its use for each sub-region. This includes OASIS, schedules, IDC, and RT data. If for some reason the data could not be provided

by receiving entity, but could be from the sending entity, then the sending entity's data were used.

One of the goals of the study was to determine if there was a correlation among the limitations identified by OASIS, market, and IDC data. The various intricacies of the study made it difficult to correlate data from three different sources.

The table below summarizes the result for the whole of the Eastern Interconnection. Table 6.1 summarizes the top three interfaces based on metrics created for the interfaces. Table 6.2 summarizes the top interface in each sub-region based on metrics created for the interfaces. Table 6.3 summarizes the top three sub-regions and top flowgates based on metrics created for the sub-region.

Metric	Top 3 Interfaces		
	Top Interface 1 Count	Top Interface 2 Count	Top Interface 3 Count
Confirmed Firm TSR Count	ISONE > NYISO 19808	SOCO > VACAR 3121	SOCO > MISO 942
Confirmed Firm Reservation GWh	PJM > NYISO 21428	MISO > SPP 19880	MISO > PJM 14395
Refused Firm TSR Count	MISO > PJM 1708	TVA > PJM 1660	MISO > TVA 193
Refused Firm Reservation GWh	MISO > PJM 178400	TVA > PJM 145767	MISO > TVA 2641
% Refusal Firm TSR Count	MISO > TVA 91.9	MISO > SOCO 91.89	TVA > PJM 88.77
% Refusal Firm Reservation GWh	MISO > NON RTO MIDWEST 100	TVA > PJM 97.6	MISO > PJM 92.53
Confirmed Non-Firm TSR Count	PJM > MISO 10748	MISO > PJM 5508	PJM > NYISO 5462
Confirmed Non-Firm Reservation GWh	PJM > NYISO 17024	PJM > MISO 8557	PJM > VACAR 1304
Refused Non-Firm TSR Count	MISO > PJM 3390	TVA > PJM 733	MISO > SPP 444
Refused Non-Firm Reservation GWh	TVA > VACAR 5378	MISO > PJM 2440	VACAR > PJM 1491
% Refusal Non-Firm TSR Count	TVA > NON RTO MIDWEST 100	MISO > TVA 50.99	TVA > PJM 41.39

Metric		Top 3 Interfaces		
		Top Interface 1 Count	Top Interface 2 Count	Top Interface 3 Count
% Refusal Non-Firm Reservation GWh		TVA > NON RTO MIDWEST 100	TVA > VACAR 99.67	MISO > SOCO 96.3
Firm TRU75 Count		SOCO > MISO 683	ISONE > NYISO 455	TVA > VACAR 222
Firm TRU90 Count		SOCO > MISO 347	ISONE > NYISO 298	SOCO > TVA 70
Non-Firm TRU75 Count		PJM > MISO 167	PJM > TVA 28	TVA > VACAR 24
Non-Firm TRU90 Count		PJM > TVA 21	PJM > MISO 10	PJM > NYISO 5
Zero Firm ATC Count		TVA > NON RTO MIDWEST 8760	SPP > MISO 8733	TVA > PJM 8687
Non-Firm Zero ATC Count		MISO > TVA 4511	SPP > MISO 3242	MISO > SPP 3061
Schedule U75 Count		TVA > VACAR 2451	TVA > PJM 869	SOCO > MISO 608
Schedule U90 Count		TVA > VACAR 838	SOCO > MISO 287	ISONE > NYISO 179
Actual U75 Count		ISONE > NYISO 2155	NYISO > PJM 1010	TVA > SOCO 182
Actual U90 Count		ISONE > NYISO 1233	NYISO > PJM 638	TVA > SOCO 58
Schedule Above TTC Count		TVA > VACAR 447	ISONE > NYISO 135	SOCO > TVA 44
Firm TLR	Duration Hours	None		
	Count	None		
	MWh	None		
Non-Firm TLR	Duration Hours	MISO > PJM 643	Non RTO Midwest > PJM 268	PJM > VACAR 245
	Count	NYISO > PJM 75227	MISO > PJM 53016	PJM > VACAR 29804
	MWh	MISO > PJM 1180	Non RTO Midwest > PJM 579	NYISO > ISONE 441

Table 6.1: Top 3 Interfaces Based on Metrics Created for the Interfaces

Metric	Sub-region								
	PJM	MISO	Non RTO Midwest	VACAR	SPP	TVA	SOCO	NYISO	ISONE
Confirmed Firm TSR Count	PJM > MISO 323	SOCO > MISO 942	MISO > NON RTO MIDWEST 120	SOCO > VACAR 3121	MISO > SPP 33	SOCO > TVA 311	SOCO > VACAR 3121	ISONE > NYISO 19808	ISONE > NYISO 19808
Confirmed Firm Reservation GWh	PJM > NYISO 21428	MISO > SPP 19880	NON RTO MIDWEST > SPP 17323	SOCO > VACAR 13900	MISO > SPP 19880	PJM > TVA 9454	SOCO > VACAR 13900	PJM > NYISO 214428	ISONE▫NYISO 4037
Refused Firm TSR Count	MISO > PJM 1708	MISO > PJM 1708	PJM > NON RTO MIDWEST 9	SOCO > VACAR 79	SPP > MISO 27	TVA > PJM 1660	TVA > SOCO 137	PJM > NYISO 1	None
Refused Firm Reservation GWh	MISO > PJM 178400	MISO > PJM 178400	NON RTO MIDWEST > SPP 84	SOCO > VACAR 2071	MISO > SPP 252	TVA > PJM 145767	SOCO > VACAR 2071	None	None
% Refusal Firm TSR Count	TVA > PJM 88.77	MISO > TVA 91.9	NON RTO MIDWEST > TVA 47.2	TVA > VACAR 51.75	SPP > MISO 61.36	MISO > TVA 91.9	MISO > SOCO 91.89	PJM > NYISO 1	None
% Refusal Firm Reservation GWh	TVA > PJM 97.6	MISO > PJM 92.53	TVA > NON RTO MIDWEST 0.41	TVA > VACAR 54.9	MISO > SPP 1.25	TVA > PJM 97.6	MISO > SOCO 30.91	None	None
Confirmed Non-Firm TSR Count	PJM > MISO 10748	PJM > MISO 10748	NON RTO MIDWEST > SPP 2212	VACAR > SOCO 3752	SPP > MISO 1630	TVA > PJM 1038	VACAR > SOCO 3752	PJM > NYISO 5462	None
Confirmed Non-Firm Reservation GWh	PJM > NYISO 17024	PJM > MISO 8557	NON RTO MIDWEST > SPP 475	VACAR > PJM 1238	MISO > SPP 254	TVA > PJM 648	VACAR > SOCO 1129	PJM > NYISO 17024	None

Metric	Sub-region								
	PJM	MISO	Non RTO Midwest	VACAR	SPP	TVA	SOCO	NYISO	ISONE
Refused Non-Firm TSR Count	MISO > PJM 3390	MISO > PJM 3390	NON RTO MIDWEST > SPP 746	VACAR > PJM 52	MISO > SPP 444	TVA▫PJM 733	MISO > SOCO 130	PJM > NYISO 172	None
Refused Non-Firm Reservation GWh	MISO > PJM 2440	MISO > PJM 2440	NON RTO MIDWEST > SPP 748	TVA > VACAR 5378	MISO > SPP 59	TVA > VACAR 5378	MISO > SOCO 1264	None	None
% Refusal Non-Firm TSR Count	TVA > PJM 41.39	MISO > TVA 50.99	MISO > NON RTO MIDWEST 49.7	TVA > VACAR 36.36	MISO > SPP 31.09	MISO > TVA 50.99	TVA > SOCO 46.3	PJM > NYISO 172	None
% Refusal Non-Firm Reservation GWh	TVA > PJM 67.07	MISO > TVA 91.56	TVA > NON RTO MIDWEST 100	TVA > VACAR 99.67	MISO > SPP 18.81	TVA > NON RTO MIDWEST 100	MISO > SOCO 96.3	None	None
Firm TRU75 Count	None	SOCO > MISO 683	None	TVA > VACAR 222	None	TVA > VACAR 222	SOCO > MISO 683	PJM > NYISO 8688	ISONE > NYISO 455
Firm TRU90 Count	None	SOCO > MISO 347	None	SOCO > VACAR 40	None	SOCO > TVA 70	SOCO > MISO 347	PJM > NYISO 8688	ISONE > NYISO 298
Non-Firm TRU75 Count	PJM > MISO 167	PJM > MISO 167	None	TVA > VACAR 24	None	TVA > VACAR 24	None	PJM > NYISO 2683	None
Non-Firm TRU90 Count	PJM > TVA 21	PJM > MISO 10	None	None	None	None	None	PJM > NYISO 2357	None
Zero Firm ATC Count	TVA > PJM 8687	SPP > MISO 8733	TVA > NON RTO MIDWEST 8760	VACAR > TVA 400	SPP > MISO 8733	TVA > NON RTO MIDWEST 8760	MISO > SOCO 8440	PJM > NYISO 2136	NYISO > ISONE 21

Metric	Sub-region								
	PJM	MISO	Non RTO Midwest	VACAR	SPP	TVA	SOCO	NYISO	ISONE
Non-Firm Zero ATC Count	MISO > PJM 2359	MISO > TVA 4511	NON RTO MIDWEST > MISO 1182	VACAR > SOCO 815	SPP > MISO 3242	MISO > TVA 4511	MISO > SOCO 1506	PJM > NYISO 2062	NYISO > ISONE 21
Schedule U75 Count	TVA > PJM 869	SOCO > MISO 608	None	TVA > VACAR 2451	None	TVA > VACAR 2451	SOCO > MISO 608	ISONE > NYISO 273	ISONE > NYISO 273
Schedule U90 Count	TVA > PJM 60	SOCO > MISO 287	None	TVA > VACAR 838	None	TVA > VACAR 838	SOCO > MISO 287	ISONE > NYISO 179	ISONE > NYISO 179
Actual U75 Count	NYISO > PJM 1010	TVA > MISO 174	None	VACAR > PJM 556	None	TVA > SOCO 182	SOCO > MISO 890	ISONE > NYISO 2155	ISONE > NYISO 2155
Actual U90 Count	NYISO > PJM 638	TVA > MISO 49	None	VACAR > PJM 329	None	TVA > SOCO 58	SOCO > MISO 573	ISONE > NYISO 1233	ISONE > NYISO 1233
Schedule Above TTC Count	PJM > NYISO 1	None	None	TVA > VACAR 447	None	TVA > VACAR 447	SOCO > MISO 193	ISONE > NYISO 135	ISONE > NYISO 135
Firm TLR Duration Hours	None	None	None	None	None	None	None	None	None
Firm TLR MWh	None	None	None	None	None	None	None	None	None
Firm TLR Count	None	None	None	None	None	None	None	None	None
Non-Firm TLR Duration Hours	MISO > PJM 643	MISO > PJM 643	NON RTO MIDWEST > PJM 268	PJM > VACAR 245	SPP > MISO 86	TVA > PJM 162	SOCO > VACAR 161	NYISO > ISONE 168	NYISO > ISONE 168

Metric	Sub-region								
	PJM	MISO	Non RTO Midwest	VACAR	SPP	TVA	SOCO	NYISO	ISONE
Non-Firm TLR MWh	NYISO > PJM 75227	NYISO > PJM 75227	NON RTO MIDWEST > PJM 9810	PJM > VACAR 29804	SPP > MISO 1839	TVA > PJM 12073	SOCO > VACAR 4939	NYISO > PJM 75227	NYISO > ISONE 26600
Non-Firm TLR Count	MISO > PJM 1180	MISO > PJM 1180	NON RTO MIDWEST > PJM 579	VACAR > PJM 350	SPP > MISO 178	TVA > PJM 328	SOCO > VACAR 261	NYISO > ISONE 441	NYISO > ISONE 441

Table 6.2: Top Interface in Each Sub-Region Based on Metrics Created for the Interfaces

Metric		Top 3 Sub-Region		
		Top 1	Top 2	Top 3
TLR Firm based on Duration	Sub-Region	None	None	None
	Sub-Region Hours			
	Top Flowgate			
	Flowgate Hours			
TLR Firm based on MWh	Sub-Region	None	None	None
	Sub-Region MWh			
	Top Flowgate			
	Flowgate MWh			
TLR Firm based on Count	Sub-Region	None	None	None
	Sub-Region count			
	Top Flowgate			
	Flowgate count			
TLR Non-Firm based on Duration	Sub-Region	MISO	NYISO	Non RTO Midwest
	Sub-Region Hours	871	327	304
	Top Flowgate	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	CENTRAL EAST TIES	Pierce- Foster 345KV
	Flowgate Hours	181	168	138
TLR Non-Firm based on MWh	Sub-Region	NYISO	MISO	PJM
	Sub-Region MWh	101828	67348	59804
	Top Flowgate	ONTARIO-ITC	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	310 - Person-Halifax 230 kV line l/o Wake-Heritage 500 kV
	Flowgate MWh	75227	21171	39218
TLR Non-Firm based on Count	Sub-Region	MISO	NYISO	Non RTO Midwest
	Sub-Region count	1639	825	655
	Top Flowgate	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	CENTRAL EAST TIES	Pierce- Foster 345KV
	Flowgate count	539	441	361
Zero Firm AFC Count		None	None	None
Zero Non-Firm AFC Count		None	None	None
Binding Constraint based on Count	Sub-Region	SPP	NYISO	PJM
	Sub-Region count	10421	10324	897

Metric		Top 3 Sub-Region		
		Top 1	Top 2	Top 3
Binding Constraint based on Count	Top Flowgate	WDWFPLTATNOW	CENTRAL EAST - VC	Laporte-Michigan City 138 1 (MISO)
	Flowgate count	3154	2520	300
Binding Constraint based on RT Congestion Cost	Sub-Region	SPP	ISONE	PJM
	Sub-Region Total Congestion Cost	$ 131 M	$ 20 M	$ 19 M
Binding Constraint based on RT Congestion Cost	Top Flowgate	WDWFPLTATNOW	326_SEABROOK_394-1_A	Dixon-McGirr Road 10714 138 (COMED)
	Flowgate Total Congestion Cost	$ 50 M	$ 10 M	$ 6 M
Market Flow Binding Constraint based on Count	Sub-Region	MISO	SPP	PJM
	Sub-Region Count	2662	1256	921
Market Flow Binding Constraint based on Count	Top Flowgate	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	TMP144_21263	Laporte-Michigan City 138 1 (MISO)
	Flowgate count	1085	514	319
Market Flow Binding Constraint based on Market Settlement Cost	Sub-Region	MISO	PJM	SPP
	Sub-Region Total Congestion Cost	$ 20 M	$ 9 M	$ 7 M
Market Flow Binding Constraint based on Market Settlement Cost	Top Flowgate	Oak_Grove_Mercer161_flo_Nelson_ElectricJct	H471-Quad Cities 0404 345 (COMED)	CBLS56ROLMAD
	Flowgate Total Congestion Cost	$ 6 M	$ 2 M	$ 3 M

Table 6.3: Top 3 Sub-Regions and Top Flowgate Based on Metrics Created for the Sub-Region

Appendix A: Data Sources

This appendix lists the data sources and assumptions used in this study.

Interface	OASIS Node/Path Name	Data Availability		Comments
		Actual Flow	TTC	
MISO-TVA	MISO/MISO-TVA	Yes	Yes	
MISO-Non RTO Midwest	MISO/MISO-LGEE	Yes	Yes	
	MISO/MISO-AECI	Yes	Yes	
MISO-PJM	MISO/MISO-PJM	Yes	Yes	
MISO-SOCO	MISO/MISO-AEC	Yes	Yes	
	MISO/MISO-SOCO	Yes	Yes	
MISO-SPP	MISO/MISO-CSWS	No	Yes	For TTC, All MISO-SPP paths are added except MISO-SWPP. For actual flows, only MISO-SWPP was considered (provided by MISO) since it include actual flow on all ties.
	MISO/MISO-EDE	No	Yes	
	MISO/MISO-GRDA	No	Yes	
	MISO/MISO-KCPL	No	Yes	
	MISO/MISO-LES	No	Yes	
	MISO/MISO-MPS	No	Yes	
	MISO/MISO-NPPD	No	Yes	
	MISO/MISO-OKGE	No	Yes	
	MISO/MISO-OPPD	No	Yes	
	MISO/MISO-SECI	No	Yes	
	MISO/MISO-SPA	Yes	Yes	
	MISO/MISO-SPS	No	Yes	
	MISO/MISO-WFEC	No	Yes	
	MISO/MISO-WR	No	Yes	
	MISO/MISO-KACY	No	Yes	
	MISO/MISO-SWPP	Yes	No	
	MISO/MISO-WAUE	No	Yes	Sub-path is included only for period WAUE joined SPP.
MISO-MAPP US	MISO/MISO-WAUE	No	Yes	Sub-path is included only for period prior to WAUE joined SPP; no actuals flow metric will be calculated as no actuals were provided.
Non RTO Midwest-PJM	LGEE/LGEE-PJM	Yes	Yes	TTC value from ATC initialization impact from LGEE OASIS.
Non RTO Midwest-MISO	MISO/AECI-MISO	Yes	Yes	
	LGEE/LGEE-MISO	Yes	Yes	TTC value from ATC initialization impact from LGEE OASIS.
Non RTO Midwest-TVA	LGEE/LGEE-TVA	Yes	Yes	
	AECI-TVA	Yes	Yes	TTC value provide by AECI.

Interface	OASIS Node/Path Name	Data Availability		Comments
		Actual Flow	TTC	
Non RTO Midwest-SPP	SWPP/AECI-WFEC	No	No	AECI-SPP's OASIS data (ATC) is not available from either SPP or AECI.
	SWPP/AECI-OKGE	No	No	
	SWPP/AECI-CSWS	No	No	
	SWPP/AECI-WR	No	No	
	SWPP/AECI-GRDA	No	No	
	SWPP/AECI-KCPL	No	No	
	SWPP/AECI-EDE	No	No	
	AECI-SPP	No	No	
PJM-MISO	PJM-ALTE	Yes	Yes	This data from provided by PJM.
	PJM-ALTW	Yes	Yes	
	PJM-MEC	Yes	Yes	
	PJM-WEC	Yes	Yes	
	PJM-NIPS	Yes	Yes	
	PJM-AMIL	Yes	Yes	
	PJM-IPL	Yes	Yes	
	PJM-CIN	Yes	Yes	
	PJM-MECS	Yes	Yes	
PJM-NYISO	PJM-NYIS	Yes	Yes	
PJM-VACAR	PJM-DUK	Yes	Yes	
	PJM-CPLE	Yes	Yes	
	PJM-CPLW	Yes	Yes	
PJM-TVA	PJM-TVA	Yes	Yes	
PJM-Non RTO Midwest	PJM-LGEE	Yes	Yes	
SOCO-VACAR	SOCO/SOCO-SC	Yes	Yes	
	SOCO/SOCO-SCEG	Yes	Yes	
	SOCO/SOCO-DUK	Yes	Yes	
SOCO-MISO	SOCO/SOCO-MISO	Yes	Yes	
SOCO-TVA	SOCO/SOCO-TVA	Yes	Yes	
SPP-Non RTO Midwest	SWPP/EDE-AECI	Yes	No	SPP-AECI's ACTUAL DATA and OASIS data is not available, No metric Calculation will be done.
	SWPP/EES-AECI	Yes	No	
	SWPP/GRDA-AECI	Yes	No	
	SWPP/OKGE-AECI	Yes	No	
	SWPP/SPA-AECI	Yes	No	
	SWPP/WFEC-AECI	Yes	No	
	SWPP/WR-AECI	Yes	No	
	SWPP/CSWS-AECI	Yes	No	
SPP-MISO	SWPP/CSWS-EES	No	Yes	Using data from MISO's CSWS-MISO.

Interface	OASIS Node/Path Name	Data Availability		Comments
		Actual Flow	TTC	
	MISO/LES-MISO	No	Yes	For TTC, all SPP-MISO paths are added except SWPP-MISO which was taken from MISO's OASIS. For actual flow, only SWPP-MISO was considered provided by SWPP since it include actual flow on all ties.
	MISO/OKGE-MISO	No	Yes	
	MISO/EDE-MISO	No	Yes	
	MISO/SECI-MISO	No	Yes	
	MISO/WFEC-MISO	No	Yes	
	MISO/CSWS-MISO	No	Yes	
	MISO/NPPD-MISO	No	Yes	
	MISO/OPPD-MISO	No	Yes	
	MISO/SPA-MISO	No	Yes	
	MISO/WR-MISO	No	Yes	
	MISO/GRDA-MISO	No	Yes	
	MISO/KACY-MISO	No	Yes	
	MISO/KCPL-MISO	No	Yes	
	MISO/MPS-MISO	No	Yes	
	MISO/SPS-MISO	No	Yes	
SPP-MAPP US	SWPP/NPPD-WAUE	No	No	No Data from SWPP, No metric Calculation will be done.
TVA-MISO	TVA/TVA-EES	No	Yes	Valid till 05/26/2015, actuals from TVA-MISO provided by MISO.
	TVA/TVA-MISO.N	No	Yes	Valid from 05/27/2015, actuals from TVA-MISO provided by MISO.
	TVA/TVA-MISO.S	No	Yes	
	TVA/TVA-MISO	No	Yes	Valid till 05/26/2015, actuals from TVA-MISO provided by MISO.
TVA-VACAR	TVA/TVA-CPLW	No	Yes	Actuals from VACAR.
	TVA/TVA-DUK	No	Yes	
TVA-SOCO	TVA/TVA-SOCO	No	Yes	Actuals from SOCO.
TVA-PJM	TVA/TVA-PJM	No	Yes	Actuals from PJM.
TVA-Non RTO Midwest	TVA/TVA-AECI	No	Yes	Actuals from AECI.
	TVA/TVA-LGEE	No	Yes	Actuals from LGEE.
VACAR-TVA	DUK/DUK-TVA	Yes	Yes	
	CPL/CPLW-TVA	Yes	Yes	
VACAR-SOCO	SCEG/SCEG-SOCO	Yes	Yes	
	DUK/DUK-SOCO	No	Yes	
	SC/SC-SOCO	Yes	Yes	
VACAR-PJM	DUK/DUK-PJM	Yes	Yes	
	CPL/CPLE-PJM	Yes	Yes	
	CPL/CPLW-PJM	Yes	Yes	

Interface	OASIS Node/Path Name	Data Availability		Comments
		Actual Flow	TTC	
ISNE-NYISO	NE/ISNE/ISNE-NYIS/ISNE PTF-NY NE BORDER	Yes	Yes	
	NE/ISNE/ISNE-NYIS/ISNE PTF-LI CT NNC	Yes	Yes	
	NE/ISNE/ISNE/ISNE PTF-LI CT CSC	Yes	Yes	
NYISO-ISNE	NPX-1385	Yes	Yes	
	NPX-CSC	Yes	Yes	
	NYISO-ISONE	Yes	Yes	
NYISO-PJM	NYISO-PJM	Yes	Yes	
	PJM-NEPTUNE	Yes	Yes	

Table A1: Interfaces Used

Interface	POR	POD
MISO-SPP	MEC	NPPD
MISO-SPP	EES	CSWS
MISO-SPP	EES	KCPL
MISO-SPP	EES	MPS
MISO-SPP	EES	SPA
MISO-SPP	EAI	SPA
MISO-SPP	EES	WR
MISO-SPP	CLEC	CSWS
MISO-SPP	MEC	OPPD
MISO-SPP	AMRN	EDE
MISO-SPP	CIN	WR
MISO-SPP	AMRN	NPPD
MISO-SPP	AMMO	EDE
MISO-SPP	CIN	EDE
MISO-SPP	AMMO	CSWS
MISO-SPP	AMRN	OKGE
MISO-SPP	IPL	CSWS
MISO-SPP	AMRN	CSWS
MISO-SPP	EES	WFEC
MISO-SPP	AMRN	OPPD
MISO-SPP	AMRN	SPS
MISO-SPP	AMMO	SPS

Interface	POR	POD
MISO-SPP	AMMO	OPPD
MISO-SPP	CWLD	CSWS
MISO-SPP	AMRN	WFEC
MISO-SPP	AMRN	KCPL
MISO-SPP	AMMO	KCPL
MISO-SPP	AMIL	CSWS
MISO-SPP	CWLD	OPPD
MISO-SPP	AMRN	WR
MISO-SPP	CWLD	WR
MISO-SPP	AMIL	SPS
MISO-SPP	AMIL	NPPD
MISO-SPP	CWLD	NPPD
MISO-SPP	CIN	CSWS
MISO-SPP	AMMO	NPPD
MISO-SPP	IPL	SPS
MISO-SPP	IPL	SPA
MISO-SPP	AMRN	SPA
MISO-SPP	AMIL	OPPD
MISO-SPP	CWLD	SPA
MISO-SPP	AMMO	WFEC
MISO-SPP	MEC	OKGE
MISO-SPP	MEC	WR
MISO-SPP	AMIL	KCPL
MISO-SPP	CIN	NPPD
MISO-SPP	AMMO	WR
MISO-SPP	ALTW	NPPD
MISO-SPP	CWLD	WFEC
MISO-SPP	CIN	SPA
MISO-SPP	LAGN	SPA
MISO-SPP	ALTE	CSWS
MISO-SPP	EAI	CSWS
MISO-SPP	WEC	MPS
MISO-SPP	EAI	OKGE
MISO-SPP	AMIL	KACY
MISO-SPP	MEC	KCPL
MISO-SPP	AMRN	MPS
MISO-SPP	CIN	OKGE
MISO-SPP	AMRN	SPRM
MISO-SPP	AMMO	OKGE

Interface	POR	POD
MISO-SPP	EES	EDE
MISO-SPP	MEC	CSWS
MISO-SPP	EES	OKGE
MISO-SPP	IPL	MPW
MISO-SPP	MEC	EDE
MISO-SPP	CIN	OPPD
MISO-SPP	IPL	OKGE
MISO-SPP	IPL	WFEC
MISO-SPP	NIPS	CSWS
MISO-SPP	MDU	WFEC
MISO-SPP	ALTW	CSWS
MISO-SPP	CWLD	KCPL
MISO-SPP	CONS	CSWS
MISO-SPP	HE	CSWS
MISO-SPP	EES	NPPD
MISO-SPP	LAFA	CSWS
MISO-SPP	LAGN	CSWS
MISO-SPP	DECO	CSWS
MISO-SPP	IPL	KCPL
MISO-TVA	AMIL	TVA
MISO-TVA	ALTW	TVA
MISO-TVA	EES	TVA
MISO-TVA	LAGN	TVA
MISO-TVA	AMMO	TVA
MISO-TVA	CIN	TVA
MISO-TVA	ALTE	TVA
MISO-TVA	EAI	TVA
MISO-TVA	DECO	TVA
MISO-SOCO	AMIL	SOCO
MISO-SOCO	LAGN	SOCO
MISO-SOCO	EES	SOCO
MISO-SOCO	DECO	SOCO
MISO-SOCO	CIN	SOCO
MISO-SOCO	EAI	SOCO
MISO-SOCO	EEI	SOCO
MISO-SOCO	IPL	SOCO
MISO-SOCO	EAI	AEC
MISO-SOCO	AMIL	AEC
MISO-SOCO	SME	SOCO

Interface	POR	POD
MISO-SOCO	ALTE	SOCO
MISO-SOCO	CWLD	SOCO
MISO-SOCO	BREC	SOCO
MISO-SOCO	ALTW	SOCO
MISO-SOCO	WEC	SOCO
MISO-SOCO	AMMO	SOCO
MISO-PJM	ALTE	PJM
MISO-PJM	IPL	PJM
MISO-PJM	CIN	PJM
MISO-PJM	AMIL	PJM
MISO-PJM	MEC	PJM
MISO-PJM	AMMO	PJM
MISO-PJM	CWLD	PJM
MISO-PJM	CONS	PJM
MISO-PJM	WEC	PJM
MISO-PJM	WPS	PJM
MISO-PJM	DECO	PJM
MISO-PJM	MDU	PJM
MISO-PJM	NIPS	PJM
MISO-PJM	HE	PJM
MISO-PJM	ALTW	PJM
MISO-PJM	EES	PJM
MISO-PJM	CLEC	PJM
MISO-PJM	SME	PJM
MISO-PJM	MP	PJM
MISO-PJM	EAI	PJM
MISO-PJM	LAGN	PJM
MISO-PJM	SIGE	PJM
MISO-PJM	LAFA	PJM
MISO-PJM	SIPC	PJM
MISO-PJM	CWLP	PJM
MISO-PJM	EEI	PJM
MISO-MAPP US	MISO	WAUE
MISO-Non RTO Midwest	AMIL	LGEE
MISO-Non RTO Midwest	CIN	LGEE
MISO-Non RTO Midwest	ALTE	LGEE

Interface	POR	POD
MISO-Non RTO Midwest	EES	AECI
MISO-Non RTO Midwest	ALTW	LGEE
MISO-Non RTO Midwest	AEC	LGEE
MISO-Non RTO Midwest	AMMO	LGEE
MISO-Non RTO Midwest	CWLD	AECI
MISO-Non RTO Midwest	AMIL	AECI
MISO-Non RTO Midwest	NSP	AECI
MISO-Non RTO Midwest	BREC	LGEE
MISO-Non RTO Midwest	GRE	LGEE
Non RTO Midwest-SPP	AECI	SPP
Non RTO Midwest-TVA	LGEE	TVA
Non RTO Midwest-TVA	AECI	TVA
Non RTO Midwest-PJM	LGEE	PJM
Non RTO Midwest-MISO	LGEE	MISO
NYISO	NA	NA
PJM-VACAR	PJM	CPLE
PJM-VACAR	PJM	DUK
PJM-TVA	PJM	TVA
PJM-Non RTO Midwest	PJM	LGEE
PJM-NYISO	PJM	NYIS
PJM-NYISO	PJM	NEPTUNE
PJM-NYISO	PJM	LINDENVFT
PJM-MISO	PJM	WEC
PJM-MISO	PJM	CIN
PJM-MISO	PJM	ALTE
PJM-MISO	PJM	MECS
PJM-MISO	PJM	AMIL
PJM-MISO	PJM	IPL

Interface	POR	POD
PJM-MISO	PJM	ALTW
PJM-MISO	PJM	MEC
VACAR-TVA	YAD	TVA
VACAR-TVA	DUK	TVA
VACAR-TVA	CPLE	TVA
VACAR-TVA	SC	TVA
VACAR-SOCO	DUK	SOCO
VACAR-SOCO	CPLE	SOCO
VACAR-SOCO	YAD	SOCO
VACAR-SOCO	SCEG	SOCO
VACAR-SOCO	SC	SOCO
VACAR-PJM	DUK	PJM
VACAR-PJM	CPLE	PJM
VACAR-PJM	YAD	PJM
VACAR-PJM	YAD	PJM
VACAR-PJM	SC	PJM
SOCO-VACAR	SOCO	DUK
SOCO-VACAR	SOCO	SC
SOCO-VACAR	SOCO	SCEG
SOCO-VACAR	AEC	DUK
SOCO-TVA	SOCO	TVA
SOCO-MISO	SOCO	MISO
TVA-VACAR	TVA	DUK
TVA-VACAR	TVA	CPLW
TVA-SOCO	TVA	SOCO
TVA-Non RTO Midwest	TVA	AECI
TVA-Non RTO Midwest	TVA	LGEE
TVA-MISO	TVA	MISO
ISONE-NYISO	ISNE PTF	NY NE BORDER
ISONE-NYISO	ISNE PTF	LI CT NNC
ISONE-NYISO	ISNE PTF	LI CT CSC
SPP-MISO	KCPL	AMRN
SPP-MISO	OPPD	AMRN
SPP-MISO	CSWS	EES
SPP-MISO	CSWS	AMRN
SPP-MISO	KCPL	MEC
SPP-MISO	OPPD	MEC

Interface	POR	POD
SPP-MISO	SPA	AMRN
SPP-MISO	OKGE	MEC
SPP-MISO	WR	AMRN
SPP-MISO	SPS	AMRN
SPP-MISO	NPPD	AMRN
SPP-MISO	OKGE	AMRN
SPP-MISO	WR	EES
SPP-MISO	WFEC	AMRN
SPP-MISO	EDE	AMRN
SPP-MISO	NPPD	MEC
SPP-MISO	INDN	AMRN
SPP-MISO	KACY	AMRN
SPP-MISO	SPS	MEC
SPP-MISO	MPS	AMRN
SPP-MISO	SPA	EES
SPP-MISO	CSWS	CLEC
SPP-MISO	NPPD	NSP
SPP-MAPP US	OPPD	WAUE
SPP-MAPP US	NPPD	WAUE
SPP-MAPP US	KCPL	WAUE
SPP-MAPP US	KACY	WAUE
SPP-MAPP US	LES	WAUE
SPP-MAPP US	SPS	WAUE

Table A2: POR-POD list

Sub-Region	Members	Comment
PJM	PJM	
MISO	MISO	
NYISO	NYISO	
Non RTO Midwest	LGEE	
Non RTO Midwest	AECI	
TVA	TVA	
SOCO	SOCO	
VACAR	YAD	
VACAR	DUK	
VACAR	CPLE	
VACAR	SC	

Sub-Region	Members	Comment
VACAR	SCEG	
ISONE	ISNE	
SWPP	SWPP	
SWPP	WAUE	After 10/01/2015
MAPP US	WAUE	Until 09/30/2015

Table A3: Sub-Regions Used

Appendix B: Actual Flow Calculation Examples

This Appendix explains how actual flow is utilized in the metrics calculation when actual flow received from the sub-region is a net value instead of directional. This appendix provides calculation examples for both net and directional cases. MISO, Non-RTO, and VACAR provided directional actual flow data. PJM, ISONE, SOCO, SPP, and NYISO provided net actual flow data.

1. **MISO Sub-Region (Example for Directional Actual Flow)**

   MISO provided directional data. For the MISO to PJM interface, MISO provided a directional "delivered flow" value, and this "delivered flow" was used for calculating the Utilization metric with the TTC taken from MISO's OASIS. Similarly, for the PJM to MISO interface, MISO provided a directional "received flow" value, and this "received flow" was used for calculating the Utilization metric with TTC taken from MISO's OASIS.

The following table is an example of actual flow and the TTC data provided by MISO for the PJM to MISO and MISO to PJM interfaces.

Hour Beginning	Actual Flow from MISO to PJM			MISO-PJM (MISO database)	PJM-MISO (MISO database)
CST	Received	Delivered	Net	TTC	TTC
2015-01-01 00	-9,496	7,284	-2,212	18209	17872
2015-01-01 01	-9,262	7,143	-2,119	18450	18302
2015-01-01 02	-9,130	7,123	-2,007	18615	18182
2015-01-01 03	-8,962	6,990	-1,972	18457	18373
2015-01-01 04	-8,776	6,892	-1,884	18398	18310
2015-01-01 05	-8,660	6,591	-2,069	18629	18469
2015-01-01 06	-8,826	6,862	-1,964	18459	18112
2015-01-01 07	-8,875	6,742	-2,133	18574	18243

The following formulas were used to calculate Utilization for the two interfaces mentioned above:

1. MISO to PJM Actual flow utilization= $\frac{Delivered\ Actual\ Data}{MISO\ to\ PJM\ TTC\ (MISO\ database)}$*100.
2. PJM to MISO Actual flow utilization= $\frac{Received\ Actual\ Data}{PJM\ to\ MISO\ TTC\ (MISO\ database)}$*100.

The example below shows how Utilization is calculated for the first hour:

1. MISO to PJM Actual flow utilization= $\frac{7284}{18209}$*100 = 40%.

2. PJM to MISO Actual flow utilization= $\frac{9496}{17872}$*100 = 53.13%.

Utilization is calculated on a yearly basis in the study report, the following table lays this out for only the first two hours of the year.

Time	PJM (Data by MISO)		MISO-PJM	PJM-MISO	MISO-PJM	PJM-MISO	MISO-PJM		PJM-MISO	
	Received	Delivered	TTC	TTC	Utilization= (Delivered/MISO to PJM TTC)	Utilization= (Received/MISO to PJM TTC)	U75	U90	U75	U90
2015-01-01 00	-9,496	7,284	18209	17872	40.00%	53.13%	0	0	0	0
2015-01-01 01	-9,262	7,143	18450	18302	38.72%	50.60%	0	0	0	0

2. PJM Sub-Region (Example for Net Actual Flow)

PJM provided net actual data instead of directional data. PJM data were provided on a sub-path basis. For a particular interface with multiple sub-paths, some of the sub-paths may have positive actual data posted and some sub-paths may have negative actual data for the hour; these values were added to get a final net actual flow value. The PJM to NYISO hourly value was calculated by adding sub-paths. All of these TTC values used for PJM to NYISO and NYISO to PJM were from PJM's dataset. For PJM to NYISO, Utilization metrics were calculated by using positive net actual data, and for NYISO to PJM, Utilization metrics were calculated by using negative net actual data.

PJM Data					Calculation used in this study
Beginning EPT	HUDS[3]	LIND[4]	NEPT[5]	NYIS[6]	PJM to NYISO
	ACTUAL	ACTUAL	ACTUAL	ACTUAL	Net Actual Flow
02/19/2015 10:00	-104	307	-166	519	556
02/19/2015 11:00	-104	308	-170	-402	-368

The following formulas were used to calculate Utilization for the two interfaces mentioned above:

1. NYISO to PJM Actual flow utilization= $\frac{Negative\ Net\ Actual\ Data}{NYISO\ to\ PJM\ TTC\ (PJM\ database)}$*100.

[3] Hudson Transmission Service
[4] Linden VFT Transmission Service
[5] Neptune Regional Transmission System, LLC
[6] New York Independent System

2. PJM to NYISO Actual flow utilization= $\frac{Positive\ Net\ Actual\ Data}{PJM\ to\ NYISO\ TTC\ (PJM\ database)}$*100.

The example below shows how Utilization is calculated for one hour:

1. NYISO to PJM Actual flow utilization= $\frac{556}{1837}$*100 = 30.26%.
2. PJM to NYISO Actual flow utilization= $\frac{368}{8667.2}$*100 = 4.24%.

Utilization is calculated on a yearly basis in the study report. The following table lays out utilization for only two hours of the year.

Time	PJM-NYISO (PJM's data)	PJM-NYISO	NYISO-PJM	PJM-NYISO	NYISO-PJM	PJM-NYISO		NYISO-PJM	
	Net Actuals	TTC	TTC	Utilization=(Positive Net Actual/PJM to NYISO TTC)	Utilization=(Negative Net Actual/NYISO to PJM TTC)	U75	U90	U75	U90
02/19/2015 10:00	556	1837.32	8667.2	30.26%	------	0	0	-----	-----
02/19/2015 11:00	-368	1837.32	8667.2	-------	4.24%	-----	-----	0	0

While the study team looked at TTC when calculating Utilization metrics, as specified in the methods above, some of the TTC values were found to be 0 MW for some of the hours. If more than 25% of the total count of a TTC's value was found to be 0 MW, then the TTC used for that interface was from the sink side. For interfaces where less than 25% of the total count was found to be 0 MW, then the TTC from the source side was used. For those hours having a TTC of 0 MW, Utilization was not calculated.

Appendix C: List of most limiting flowgates provided by Sub-regions

1. PJM Sub-Region

Number	Flowgate Name
1	15518-Garden Plain 138 l/o Quad Cities-Rock Crk 345
2	Breed-Wheatland 345 (flo) Jefferson-Rockport 765
3	LORETTO-WILTON 345 (FLO) DRESDEN-PONTIAC 345 + XFMR
4	Wempletown-Paddock 345 (flo) Wempletown-Rockdale 345
5	08GRDALE-Miami Fort (flo) Clifty Creek-Trimble 345
6	Kyger Creek-SPORNAEP ck2 345 (flo) SPORNAEP-Kyger Creek ck1 345
7	Zion EC -Zion Sta345 (flo) Zion-Pleasant Prairie 345
8	Twin Branch-Argenta 345kV l/o Cook-Palisades + Benton Harbor-Palisades 345kV Lines
9	Cooper-St Joe 345 + Cooper-Fairpoint 345
10	BROKAW-80PONTIAC 345 (FLO) BLUE MOUND-80PONTIAC 345
11	155 Nelson 345/138kV TR82 l/o Byron-LeeCo 345kV
12	Trimble Co.-Clifty Creek 345-Rockport-Jefferson 765
13	WEMPLETOWN 345/138 XFMR(FLO) CHERRY VALLEY 345/138/34.5 XFMRS
14	Cordova-Nelson 345 (flo) Quad Cities-H471 345
15	Madison-Woodsdale 345kV (DEOK)
16	Monroe-Bay Shore 345
17	974 Zion-22 Zion 345 kV l/o Pleasant Prairie-22 Zion 345kV
18	Monroe-Bay Shore 345 (flo) Lulu-Allen Junction 345
19	Loretto-Wilton Center 345 kV l/o Pontiac-Dresden 345 kV + TR82
20	Nelson-Elect Jct 345 _B (flo) Cherry Valley-Silver Lake 345 _R
21	Kyger Creek - Sporn 345 kV
22	Madison-Cross Street 138 (flo) Desoto-Fall Creek 345

2. MISO Sub-Region

FG_OPC for AFC	FG Description	FGID	LBA	Reciprocal Entities
DORROS__PTDF	D602F_500KV	6060	MHEB,NSP	MISO,MAPP
ANOPHIMABANO	Arkansas_ANO__PleasantHills500_ftlo_Arkansas_Mabelvale500	1967	EES	MISO,SWPP
RUSDARANOFTS	RusselvilleSouth_DardanelleDam_161kV_flo_ANO_FtSmith_500kV	5267	EES,OKGE, SPA	MISO,TVA,SWPP
FRPTWIFRPHNL	Freeport__Twinkletown_230_flo_Freeport__Hornlake_230	6783	EES	MISO,TVA,SWPP
RUERUSANOFSM	Russellvil_E_Russellvil_S_161kv_FTLO_ANO_Ft_Smith_500kv	1973	EAI	MISO,TVA

FG_OPC for AFC	FG Description	FGID	LBA	Reciprocal Entities
DO7DO6SARLON	Dolet_Hills_345_230_Auto_flo_Longwood_Sarepta_345	5424	CLEC	MISO,SWPP
MDVGWXKUISSW	Nelson_TR_84_loss_of_Nelson_H471_15504_345kV	3329	BREC	MISO,PJM
OAGGBRELCNEL	Oak_Grove_Galesburg_flo_Nelson_ElectricJct	3429	AMIL,MEC	MISO,PJM
MCTAPMCSHAMA	McCracken Tap-McCracken 161kV (flo) Shawnee - Marshall 500kV	3090	AMIL	MISO,TVA
MELCALHOLISE	Melborne__Calico_Rock_161_ftlo_ISES__Holland_Bottoms_500	6722	EES	NO
MELCROISEDEL	Melbourne_CalicoRock_161kV_flo_ISES_Dell_500kV	1974	EAI	MISO,SWPP
JDGYRHRTKIDL	Bull_Shoals_Midway_161_ftlo_Norfork_Buford_161	6723	EAI,SPA	MISO,SWPP
BWLVKS_VKSW	Baxter_WilsonVicksburg_SE_115_ftlo_VicksburgVicksburg_W_115	6780	EES	NO
STAMENCHOCLA	StarMendanhall115_ftlo_ChoctawClay500	6818	EES	NO
OAKGALLEEBYR	Oak Grove-Galesburg 161kV (flo) Byron-LeeCo 345kV	6239	AMIL,MEC	MISO,PJM
CALNORANOFTS	CalicoRock_Norfork_161kV_flo_ANO_FtSmith_500kV	5438	SPA	MISO,SWPP,TVA
CALNORINDDEL	CalicoRock_Norfork_161kV_flo_Dell_Independence_500kV	5440	SPA	MISO,SWPP
RUNRUEANOPHI	Russelville North-RusselvilleEast 161kV_FLO_ANO_PleasantHill_500kV	6338	EAI	MISO, SWPP
COULEWSARLON	Couch__Lewisville_115__flo__Sarepta_Longwood_345	6781	EES	SWPP
LAVELEDORSTL	LaVerendry -- Letellier 230kV line (Y51L) flo Dorsey-St Leon 230kV	6160	MHEB	MISO,MAPP

3. SPP Sub-Region

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5003	BRKBETVALPIT	SWPP	MON	BROKEN BOW DAM	SPA	BETHEL	CSWS	138
5003			CON	VALLIANT	CSWS	PITTSBURG	CSWS	345

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5005	CATXFRCATXFR	SWPP	MON	CATOOSA	GRDA	CATOOSA (XF1)	GRDA	161/138
5005			CON	CATOOSA	GRDA	CATOOSA (XF2)	GRDA	161/138
5006	WODFPLRENSAN	SWPP	MON	WOODWARD	OKGE	FPL SWITCH	OKGE	138
5006			CON	RENFROW	OKGE	SAND RIDGE TAP	WFEC	138
5008	CRAASHVALLYD	SWPP	MON	CRAIG JCT	CSWS	ASHDOWN WEST	CSWS	138
5008			CON	VALLIANT	CSWS	LYDIA	CSWS	345
5011	EASTDC_NO_SO	SWPP	MON	WELSH	CSWS	EAST DC TIE	CSWS	345
5012	EASTDC_SO_NO	SWPP	MON	EAST DC TIE	CSWS	WELSH	CSWS	345
5013	LULTUPPITSEM	SWPP	MON	LULA	OKGE	TUPELO TAP	WFEC	138
5013			CON	PITTSBURG	CSWS	SEMINOLE	OKGE	345
5014	ELKXFRTUCOKU	SWPP	MON	ELK CITY	CSWS	ELK CITY	CSWS	230/138
5014			CON	TUCO	SPS	OKLAUNION	CSWS	345
5016	FTSXFRFTSXFR	SWPP	MON	FT SMITH	OKGE	FT SMITH	OKGE	500/345
5016			CON	FT SMITH	OKGE	FT SMITH	OKGE	161/500
5018	FPLWODNINBEA	SWPP	MON	FPL SWITCH	OKGE	WOODWARD	OKGE	138
5018			CON	NINE MILE	WFEC	BEARCAT	WFEC	138
5021	NUKPECVIOWIC	SWPP	MON	NEWKIRK	OKGE	PECKHAM	OKGE	138
5021			CON	VIOLA	WR	WICHITA	WR	345
5022	LACNEOEMPWIC	SWPP	MON	LACYGNE	KCPL	NEOSHO	WR	345
5022			CON	EMPORIA	WR	WICHITA	WR	345
5025	PILSCOHOLXFR	SWPP	MON	PILE	SECI	SCOTT CITY	SECI	115
5025			CON	HOLCOMB	SECI	HOLCOMB	SECI	345/115
5026	HOLXFRHOLSET	SWPP	MON	HOLCOMB	SECI	HOLCOMB	SECI	115/345
5026			CON	HOLCOMB	SECI	SETAB	SECI	345
5027	METSHAQUIGMP	SWPP	MON	METROPOLITAN	KACY	SHAWNEE	KCPL	161
5027			CON	QUIND	KACY	GM PLANT	KACY	161
5028	DICBELANTCHA	SWPP	MON	DICKINSON	WAUE	BELFIELD	WAUE	230
5028			CON	ANTELOPE VALLEY	WAUE	CHARLIE CREEK	WAUE	345
5030	TUL21SBROONE	SWPP	MON	TULSA POWER STATION	CSWS	21ST STREET TAP	CSWS	138
5030			CON	BROKEN ARROW NORTH SOUTH TAP	CSWS	ONETA	CSWS	138
5031	WELEEWELEE	SWPP	MON	WELEETKA	CSWS	WELEETKA	SPA	138
5032	MUSDENDENMUS	SWPP	MON	MUSTANG	SPS	DENVER NORTH	SPS	115

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5032			CON	DENVER SOUTH	SPS	MUSTANG	SPS	115
5034	POTXFRPECPOT	SWPP	MON	POTASH JCT	SPS	POTASH JCT	SPS	230/115
5034			CON	PECOS	SPS	POTASH JCT	SPS	230
5038	SETSCOHOLXFR	SWPP	MON	SETAB	SECI	SCOTT CITY	SECI	115
5038			CON	HOLCOMB	SECI	HOLCOMB	SECI	115/345
5039	NORDC_NO_SO	SWPP	MON	OKLAUNION	CSWS	NORTH DC TIE	CSWS	DC 345
5040	NORDC_SO_NO	SWPP	MON	NORTH DC TIE	CSWS	OKLAUNION	CSWS	DC 345
5041	RENXFRRENXFR	SWPP	MON	RENO	WR	RENO	WR	345/115
5041			CON	RENO	WR	RENO	WR	345/115
5042	NWTPATLYDVAL	SWPP	MON	N. W. TEXARKANA	CSWS	PATTERSON	CSWS	138
5042			CON	LYDIA	CSWS	VALLIANT	CSWS	345
5043	BENCHIBOESTE	SWPP	MON	BENTON	WR	CHISHOLM	WR	138
5043			CON	BOEING	WR	STEARMAN	WR	138
5044	SMASMAJECEMA	SWPP	MON	SOUTH MANHATTAN EAST	WR	SOUTH MANHATTAN	WR	115
5044			CON	JEC	WR	EAST MANHATTAN	WR	230
5050	NASHAWIATSTR	SWPP	MON	NASHUA	KCPL	HAWTHORN	KCPL	345
5050			CON	IATAN	KCPL	STRANGER CREEK	WR	345
5054	SWSANASWSFTC	SWPP	MON	SOUTHWESTERN STA	CSWS	ANADARKO	WFEC	138
5054			CON	SOUTHWESTERN STA.	CSWS	FT COBB NAT GAS	CSWS	138
5055	FRASPECOLMEA	SWPP	MON	FT RANDALL	WAUE	SPENCER	NPPD	115
5055			CON	COLUMBUS	NPPD	MEADOWGROVE	NPPD	230
5056	CARLPDLUBWOL	SWPP	MON	CARLISLE	SPS	LP-DOUD	SPS	115
5056			CON	LUBBOCK SOUTH	SPS	WOLFFORTH	SPS	230
5057	SUNXFRSUNAMO	SWPP	MON	SUNDOWN	SPS	SUNDOWN	SPS	230/115
5057			CON	SUNDOWN	SPS	AMOCO SS	SPS	230
5063	NESONENESTUL	SWPP	MON	NORTHEASTERN STA.	CSWS	ONETA	CSWS	345
5063			CON	NORTHEASTERN STA.	CSWS	TULSA NORTH	CSWS	345
5084	SWSFTCOKUTUC	SWPP	MON	SOUTHWESTERN STA	CSWS	FT COBB NAT GAS	CSWS	138
5084			CON	OKLAUNION	CSWS	TUCO	SPS	345

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5090	DOLXFRELDXFR	SWPP	MON	DOLET HILLS	CLEC	DOLET HILLS	CLEC	345/230
5090			CON	ELDORADO	EES	ELDORADO	EES	345/500
5096	MIDFRNPHAWET	SWPP	MON	MIDWEST	OKGE	FRANKLIN SWITCH	WFEC	138
5096			CON	PHAROAH	WFEC	WETUMKA	WFEC	138
5099	PITSEMPITJHN	SWPP	MON	PITTSBURG	CSWS	SEMINOLE	OKGE	345
5099			CON	PITTSBURG	CSWS	JOHNSTON COUNTY	OKGE	345
5101	SEMXFRSEMXFR	SWPP	MON	SEMINOLE	OKGE	SEMINOLE	OKGE	345/138
5101			CON	SEMINOLE	OKGE	SEMINOLE	OKGE	345/138
5196	SPSNORTH_STH	SWPP	MON	BUSHLAND	SPS	DEAF SMITH	SPS	230
5196			MON	POTTER COUNTY	SPS	NEWHART	SPS	230
5196			MON	OSAGE SWITCH	SPS	CANYON	SPS	115
5196			MON	RANDALL COUNTY	SPS	PALODUR	SPS	115
5196			MON	AMARILLO SOUTH	SPS	SWISHER	SPS	230
5201	SILDIVNWSCIM	SWPP	MON	SILVERLAKE	OKGE	DIVISION	OKGE	138
5201			CON	NORTHWEST STATION	OKGE	CIMARON	OKGE	345
5202	VALIDAVALLYD	SWPP	MON	VALLIANT	CSWS	IDABEL	CSWS	138
5202			CON	VALLIANT	CSWS	LYDIA	CSWS	345
5207	REDARCREDARC	SWPP	MON	REDBUD	OKGE	ARCADIA	OKGE	345
5207			CON	REDBUD	OKGE	ARCADIA	OKGE	345
5211	LONSARPITVAL	SWPP	MON	LONE_OAK	CSWS	SARDIS	CSWS	138
5211			CON	PITTSBURG	CSWS	VALLIANT	CSWS	345
5212	SABSEMPIRDIA	SWPP	MON	SABINE MINING	CSWS	SOUTHEAST MARSHALL	CSWS	138
5212			CON	PIRKEY	CSWS	DIANA	CSWS	345
5214	WDRCIMSPRNRW	SWPP	MON	WOODRING	OKGE	CIMARRON	OKGE	345
5214			CON	ONEOK/SPRING CREEK	OKGE	NORTHWEST STATION	OKGE	345
5215	VALLYDELDSAR	SWPP	MON	VALLIANT	CSWS	LYDIA	CSWS	345
5215			CON	EL DORADO	EES	SAREPTA	EES	345
5217	SARLONVALLYD	SWPP	MON	SAREPTA	EES	LONGWOOD	CSWS	345
5217			CON	VALLIANT	CSWS	LYDIA	CSWS	345
5218	BEAEURFLIBRO	SWPP	MON	BEAVER	SPA	EUREKA SPRING	CSWS	161
5218			CON	FLINTCREEK	CSWS	BROOKLINE	SPRM	345

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5219	STIREDSTIPEC	SWPP	MON	STILWELL	KCPL	REDEL	KCPL	161
5219			CON	STILWELL	KCPL	PECULIAR (GRAND OAKS)	MPS	345
5220	VALIANTLYDIA	SWPP	MON	VALLIANT	CSWS	LYDIA	CSWS	345
5221	REDWILLMINGO	SWPP	MON	RED WILLOW	NPPD	MINGO	SECI	345
5223	TAHH59MUSFTS	SWPP	MON	TAHLEQUAH	GRDA	HIGHWAY 59	OKGE	161
5223			CON	MUSKOGEE	OKGE	FORT SMITH	OKGE	345
5228	IATSTRNASHAW	SWPP	MON	IATAN	KCPL	STRANGER CREEK	WR	345
5228			CON	NASHUA	KCPL	HAWTHORN	KCPL	345
5241	ONEBANNESTUL	SWPP	MON	ONETA	CSWS	Broken Arrow North	CSWS	138
5241			CON	NORTHEASTERN STA.	CSWS	TULSA NORTH	CSWS	345
5242	OKMHENOKMKEL	SWPP	MON	OKMULGEE	CSWS	HENRYETTA	CSWS	138
5242			CON	OKMULGEE	CSWS	KELCO	CSWS	138
5246	ARCKAMARCNOR	SWPP	MON	ARCADIA	OKGE	JONES KAMO	OKGE	138
5246			CON	ARCADIA	OKGE	NORTHWEST STATION	OKGE	345
5247	SPPSPSTIES	SWPP	MON	OKLAUNION	CSWS	TUCO	SPS	345
5247			MON	WHEELER	CSWS	SWEETWATER	SPS	230
5247			MON	FINNEY	SPS	HITCHLAND	SPS	345
5247			MON	SHAMROCK	CSWS	MCCLEAN	SPS	115
5247			MON	LIBERAL	SECI	TEXAS CO	SPS	115
5247			MON	JERICHO	CSWS	KIRBY	SPS	115
5247			MON	BEAVER COUNTY	OKGE	HITCHLAND	SPS	345
5247			MON	BEAVER COUNTY	OKGE	HITCHLAND	SPS	345
5247			MON	BORDER	OKGE	TUCO	SPS	345
5250	SHAXFRELKXFR	SWPP	MON	SHAMROCK	CSWS	SHAMROCK	CSWS	115/69
5250			CON	ELK-CITY	CSWS	ELK-CITY	CSWS	230/138
5262	PITVALELDSAR	SWPP	MON	PITTSBURG	CSWS	VALIANT	CSWS	345
5262			CON	EL DORADO	EES	SAREPTA	EES	345
5320	WELLYDWELNWT	SWPP	MON	WELSH	CSWS	LYDIA	CSWS	345
5320			CON	WELSH	CSWS	NW TEXARKANA	CSWS	345
5324	CEDCANMIDFRA	SWPP	MON	CEDAR LANE	OKGE	CANADIAN	OKGE	138
5324			CON	MIDWEST	OKGE	FRANKLIN	WFEC	138
5325	CIMHAYCIMCZE	SWPP	MON	CIMMARON	OKGE	HAYMAKER	OKGE	138

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5325			CON	CIMMARON	OKGE	CZECH HALL	OKGE	138
5331	PRABLURSSEXG	SWPP	MON	PRATTVILLE	CSWS	BLUEBELL	OKGE	138
5331			CON	RIVERSIDE	CSWS	EXPLORER GLENPOOL	OKGE	138
5332	SHAXFRTUCOKU	SWPP	MON	SHAMROCK	CSWS	SHAMROCK	CSWS	115/69
5332			CON	TUCO	SPS	OKLAUNION	CSWS	345
5340	EROAVOFLIMON	SWPP	MON	E Rogers	CSWS	AVOCA	CSWS	161
5340			CON	FLINTCREEK	CSWS	MONET	EDE	345
5347	NESTULNESONE	SWPP	MON	Northeast Station	CSWS	TULSA NORTH	CSWS	345
5347			CON	Northeast Station	CSWS	ONETA	CSWS	345
5348	NPLSTOGTLRED	SWPP	MON	NORTH PLATE	NPPD	STOCKVILLE	NPPD	115
5348			CON	GENTLEMAN	NPPD	RED WILLOW	NPPD	345
5356	WDRWAUWDRFRE	SWPP	MON	WOODRING	OKGE	WAUKO TAP	OKGE	138
5356			CON	WOODRING	OKGE	FARMONT TAP	OKGE	138
5358	ANASEQSWSNOR	SWPP	MON	ANADARKO	WFEC	SEQUOYAH	WFEC	138
5358			CON	SOUTHWESTERN STATION	CSWS	NORGE	CSWS	138
5364	BRKXF1BRKXF2	SWPP	MON	BROOKLINE	AECI	XFR	AECI	345/161
5364			CON	BROOKLINE	SPRM	XFR	SPRM	345/161
5371	OSGCANBUSDEA	SWPP	MON	OSAGE	SPS	CANYON	SPS	115
5371			CON	BUSHLAND	SPS	DEAFSMITH	SPS	230
5375	NEORIVNEOBLC	SWPP	MON	NEOSHO	WR	RIVERTON	EDE	161
5375			CON	NEOSHO	WR	BLACKBERRY	AECI	345
5376	IPMWALDOLSWS	SWPP	MON	IPMANS	CSWS	WALLACE	CSWS	138
5376			CON	DOLET	CSWS	SW SHREVEPORT	CSWS	345
5377	NEORIVNEODEL	SWPP	MON	NEOSHO	WR	RIVERTON	EDE	161
5377			CON	NEOSHO	EDE	DELAWARE	CSWS	345
5379	PLTSMTIATSTR	SWPP	MON	PLATE CITY	MPS	SMITHVILLE	MPS	161
5379			CON	IATAN	KCPL	STRANGER CREEK	KCPL	345
5381	PLTSMTSTR87T	SWPP	MON	PLATE CITY	MPS	SMITHVILLE	MPS	161
5381			CON	STRANGER CREEK	WR	87TH STREET	WR	345
5385	HOLPLYBUCSPE	SWPP	MON	HOLCOMB	SECI	PLYMEL	SECI	115
5385			CON	BUCKNER TAP	SECI	SPEARVILLE	SECI	345
5389	CIRKNGIATEAS	SWPP	MON	CIRCLEVILLE	WR	KING HILL	WR	115

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5389			CON	IATAN	WR	EASTOWNE	WR	345
5393	IATXFRIATSTR	SWPP	MON	IATAN	MPS	XFR	WR	345/161
5393			CON	IATAN	KCPL	STRANGER CREEK	KCPL	345
5396	ARCXFRARCNOW	SWPP	MON	ARCADIA	OKGE	ARCADIA	OKGE	345/138
5396			CON	ARCADIA	OKGE	NORTHWEST STATION	OKGE	345
5400	STR87TNASHAW	SWPP	MON	STRANGER CREEK	WR	87TH STREET	WR	345
5400			CON	NASHUA	KCPL	HAWTHORN	KCPL	345
5401	SSHWALDOLXFR	SWPP	MON	SSHREVE	CSWS	WALLACE3	CSWS	138
5401			CON	DOLET	CLEC	DOLET	CLEC	345/230
5402	BRKXF2BRKXF1	SWPP	MON	BROOKLINE	SPRM	BROOKLINE	SPRM	345/161
5402			CON	BROOKLINE	AECI	BROOKLINE	AECI	345/161
5404	AFTXFRAFTMIA	SWPP	MON	AFTON	GRDA	AFTON	GRDA	161/69
5404			CON	AFTON	GRDA	MIAMI	GRDA	161
5406	SHAHAYKNOXFR	SWPP	MON	SOUTH HAYS	MIDW	HAYS	MIDW	115
5406			CON	KNOLL	MIDW	KNOLL	MIDW	230/115
5407	PENMUN87TCRA	SWPP	MON	PENTAGON	WR	MUND	WR	115
5407			CON	87TH STREET	WR	CRAIG	WR	345
5411	PITVALVALLYD	SWPP	MON	PITTSBURG	CSWS	VALLIANT	CSWS	345
5411			CON	VALLIANT	CSWS	LYDIA	CSWS	345
5413	ONEBANCLKCHA	SWPP	MON	ONETA	CSWS	BA_NORTH	CSWS	138
5413			CON	CLARKSVILLE	CSWS	CHAMBERS	CSWS	345
5416	MINXFRMINSET	SWPP	MON	MINGO	SECI	MINGO	SECI	345/115
5416			CON	MINGO	SECI	SETAB	SECI	345
5419	LYDIAVALIANT	SWPP	MON	LYDIA	CSWS	VALLIANT	CSWS	345
5420	POTXFRHITXFR	SWPP	MON	POTTER COUNTY	SPS	POTTER COUNTY	SPS	345/230
5420			CON	HITCHLAND	SPS	HITCHLAND	SPS	345/230
5421	GRAXFRGRANIC	SWPP	MON	GRAPEVINE	SPS	GRAPEVINE	SPS	230/115
5421			CON	GRAPEVINE	SPS	NICHOLS	SPS	230
5422	ELKXFRSWEWHE	SWPP	MON	ELK-CITY	CSWS	ELK-CITY	CSWS	230/138
5422			CON	SWEETWATER	CSWS	WHEELER	SPS	230
5423	GRAXFRSWEELK	SWPP	MON	GRAPEVINE	SPS	GRAPEVINE	SPS	230/115
5423			CON	SWEETWATER	CSWS	ELK CITY	CSWS	230
5424	DOLXFRLONSAR	SWPP	MON	DOLET HILLS	CLEC	DOLET HILLS	CLEC	345/230
5424			CON	LONGWOOD	CSWS	SAREPATA	EES	345

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5425	ASHCRALYDVAL	SWPP	MON	ASHDOWN WEST	CSWS	CRAIG JUNCTION	CSWS	138
5425			CON	LYDIA	CSWS	VALLIANT	CSWS	345
5426	FULPATLONSAR	SWPP	MON	FULTON	CSWS	PATMOS	EES	115
5426			CON	LONGWOOD	CSWS	SAREPATA	EES	345
5427	PENAFTGRDTON	SWPP	MON	PENSACOLA	GRDA	AFTON	GRDA	161
5427			CON	GRDA	GRDA	TONECCE	GRDA	345
5430	FIVTRBAGEEUC	SWPP	MON	FIVE TRIBES	OKGE	HANCOCK	OKGE	161
5430			CON	AGENCY	OKGE	EUCLID	OKGE	161
5431	WOOFAIWOOWAU	SWPP	MON	WOODRING	OKGE	FAIRMONT TAP	OKGE	138
5431			CON	WOODRING	OKGE	WAUKOMOS TAP	OKGE	138
5436	SPEJUDHOLPLY	SWPP	MON	SPEARVILLE	SECI	JUDSON LARGE	SECI	115
5436			CON	HOLCOMB	SECI	PLYMELL	SECI	115
5441	EDYXFREDYSEV	SWPP	MON	EDDY COUNTY	SPS	EDDY COUNTY	SPS	230/115
5441			CON	EDDY COUNTY	SPS	SEVEN RIVERS	SPS	230
5443	HOBXFRHOBCUN	SWPP	MON	HOBBS	SPS	HOBBS	SPS	230/115
5443			CON	HOBBS	SPS	CUNNINGHAM	SPS	230
5444	TUCJONTUCCAR	SWPP	MON	TUCO	SPS	JONES	SPS	230
5444			CON	TUCO	SPS	CARLISLE	SPS	230
5445	SPRCLAHUBMOR	SWPP	MON	SPRINGFIELD	SPA	CLAY	SPRM	161
5445			CON	HUBEN	AECI	MORGAN	AECI	345
5446	CIRHUTRENDAV	SWPP	MON	CIRCLE	WR	HUTCHINSON ENERGY CENTER	WR	115
5446			CON	RENO	WR	DAVIS	WR	115
5448	CIRKINHOYSTR	SWPP	MON	CIRCLEVILLE	WR	KING HILL	WR	115
5448			CON	HOYT	WR	STRANGER CREEK	WR	345
5450	HECHUNREDMIN	SWPP	MON	HUTCHINSON ENERGY CENTER	WR	HUNTSVILLE	MIDW	115
5450			CON	RED WILLOW	NPPD	MINGO	SECI	345
5452	NEORIVASBLIT	SWPP	MON	NEOSHO	WR	RIVERTON	EDE	161
5452			CON	ASBURY	WR	LITCHFIELD	EDE	161
5454	CROLATLEBTEN	SWPP	MON	CROCKETT	CSWS	LATEXO	CSWS	138
5454			CON	LEBROCK	CSWS	TENASKA	CSWS	345
5458	TURHNYSTIRED	SWPP	MON	TURNER	MPS	HONEYWELL	MPS	161
5458			CON	STILLWELL	KCPL	REDEL	KCPL	161

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5460	TUCXFRHOLFIN	SWPP	MON	TUCO	SPS	TUCO	SPS	345/230
5460			CON	HOLCOMB	SECI	FINNEY	SPS	345
5462	IATSTRIATEAT	SWPP	MON	IATAN	KCPL	STRANGER CREEK	WR	345
5462			CON	IATAN	KCPL	EASTOWNE	KCPL	345
5468	ESEIDAESEMAD	SWPP	MON	ESSEX	AECI	IDALIA	SPA	161
5468			CON	ESSEX	AECI	NEW MADRID	AECI	345
5469	MARMARMARCRE	SWPP	MON	MARYVILLE	AECI	MARYVILLE	MPS	161
5469			CON	MARYVILLE	AECI	CRESTON WEST	WAUE	161
5470	KEYFISSILSIL	SWPP	MON	KEYSTONE	SPA	FISHER TAP	AECI	138
5470			CON	SILVER CITY	AECI	SILVER CITY CSWS	CSWS	138
5471	GLAPERPERDIA	SWPP	MON	GLADEWATER	CSWS	PERDUE	CSWS	138
5471			CON	PERDUE	CSWS	DIANA	CSWS	138
5474	NORXFRNORXFR	SWPP	MON	NORTHWEST STATION	OKGE	NORTHWEST STATION	OKGE	345/138
5474			CON	NORTHWEST STATION	OKGE	NORTHWEST STATION	OKGE	345/138
5475	SEMPARSEMVAN	SWPP	MON	SEMINOLE	OKGE	PARK LANE	OKGE	138
5475			CON	SEMINOLE	OKGE	VANOS TAP	OKGE	138
5476	PECRIVCLAMUS	SWPP	MON	PECAN CREEK	OKGE	RIVERSIDE	CSWS	345
5476			CON	CLARKSVILLE	CSWS	MUSKOGEE	OKGE	345
5477	HARPOTHARROL	SWPP	MON	HARRINGTON SUB	SPS	POTTER SOUTH	SPS	230
5477			CON	HARRINGTON WEST	SPS	ROLLING HILLS	SPS	230
5478	NICGRAOKLTUC	SWPP	MON	NICHOLS	SPS	GRAPVINE	SPS	230
5478			CON	OKLAUNION	CSWS	TUCO	SPS	345
5479	DEAXFRDEAXFR	SWPP	MON	DEAFSMITH	SPS	DEAFSMITH	SPS	230/115
5479			CON	DEAFSMITH	SPS	DEAFSMITH	SPS	230/115
5480	OASXFRROOXFR	SWPP	MON	OASIS	SPS	OASIS	SPS	230/115
5480			CON	ROOSEVELT	SPS	ROOSEVELT	SPS	230/115
5481	ROOXFRROOOAS	SWPP	MON	ROOSEVELT	SPS	ROOSEVELT	SPS	230/115
5481			CON	ROOSEVELT	SPS	OASIS	SPS	230/115
5482	TUCJONPLASUN	SWPP	MON	TUCO	SPS	JONES SUB	SPS	230
5482			CON	PLANT X	SPS	SUNDOWN	SPS	230
5483	LUBXFRLUBJON	SWPP	MON	LUBBOCK SOUTH	SPS	LUBBOCK SOUTH	SPS	230/115
5483			CON	LUBBOCK EAST	SPS	JONES SUB	SPS	230

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5484	WOLYUMALLLUB	SWPP	MON	WOLFFORTH	SPS	YUMA	SPS	115
5484			CON	ALLEN	SPS	LUBBOCK SOUTH	SPS	115
5485	MUSYOAMUSAMO	SWPP	MON	MUSTANG	SPS	YOAKUM	SPS	230
5485			CON	MUSTANG	SPS	AMOCO	SPS	230
5486	MILCLEBARSAW	SWPP	MON	MILAN TAP	SECI	CLEARWATER	WR	138
5486			CON	BARBER	SECI	SAWYER	SECI	115
5487	GARHOLKSAGAR	SWPP	MON	GARDEN CITY	SECI	HOLCOMB	SECI	115
5487			CON	KANSAS AVE	SECI	GARDEN CITY	SECI	115
5489	ELPFARSONXFR	SWPP	MON	EL PASO	WR	FARBER	WR	138
5489			CON	SOONER	OKGE	SOONER	OKGE	345/138
5490	MCDFTJMCDFTJ	SWPP	MON	MCDOWELL	WR	FT JUNCTION	WR	115
5490			CON	MCDOWELL	WR	FT JUNCTION	WR	115
5491	MAICHIGORLAK	SWPP	MON	MAIZE EAST	WR	CHISHOLM	WR	138
5491			CON	GORDON EVANS	WR	LAKE RIDGE	WR	138
5492	HECHUNCLEMUR	SWPP	MON	HEC	WR	HUNTSVILLE	MIDW	115
5492			CON	CLEARWATER	WR	MURRY GILL	WR	138
5493	MOUXFRRENWIC	SWPP	MON	MOUNDRIDGE	WR	MOUNDRIDGE	WR	115/138
5493			CON	RENO	WR	WICHITA	WR	345
5494	CUDKISSPEFTD	SWPP	MON	CUDAHY	SECI	KISMET	SECI	115
5494			CON	SPEARVILLE	SECI	FT DODGE	SECI	115
5495	GRBXFRMULXFR	SWPP	MON	MULLERGREN	SECI	MULLERGREN	SECI	230/115
5495			CON	MULLERGREN	WR	MULLERGREN	WR	230/115
5496	EASXFREASSTJ	SWPP	MON	EASTOWNE	MPS	EASTOWNE	MPS	345/161
5496			CON	EASTOWNE	MPS	ST JOE	MPS	345
5497	HAWXFRHAWXFR	SWPP	MON	HAWTHORN	KCPL	HAWTHORN	KCPL	345/161
5497			CON	HAWTHORN	KCPL	HAWTHORN	KCPL	345/161
5498	CRALENGRECED	SWPP	MON	CRAIG	KCPL	LENEXA	KCPL	161
5498			CON	SHAWNEE MISSION (GREENWOOD)	KCPL	CEDAR CREEK	KCPL	161
5499	NORCROGRACRO	SWPP	MON	NORTHEAST	KCPL	CROSSTOWN	KCPL	161
5499			CON	GRAND AVE W	KCPL	CROSSTOWN	KCPL	161
5500	BARTERWEAMAY	SWPP	MON	BARBER	KACY	TERRACE	KCPL	161
5500			CON	WEATHERBY	KCPL	WOLCOTT (MAYWOOD)	KACY	161
5501	CBLS56ROLMAD	SWPP	MON	COUNCIL BLUFF	MEC	SUB 3456	OPPD	345
5501			CON	ROLLING HILLS	MEC	MADISON CO	MEC	345

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5502	CBLS56FALGRI	SWPP	MON	COUNCIL BLUFF	MEC	SUB 3456	OPPD	345
5502			CON	FALLOW AVE	MEC	GRIMES	MEC	345
5503	GRISUEGRISUD	SWPP	MON	GRAND ISLAND	NPPD	GI SUB E	NPPD	115
5503			CON	GRAND ISLAND	NPPD	GI SUB D	NPPD	115
5504	KEYOGAKEYGEN	SWPP	MON	KEYSTONE	NPPD	OGALALA	NPPD	115
5504			CON	KEYSTONE	NPPD	GENTLEMAN	NPPD	345
5506	SCHNBEOAKWIN	SWPP	MON	SCHUYLER	NPPD	NORTH BEND	NPPD	115
5506			CON	OAKLAND	NPPD	WINSLOW	NPPD	115
5507	VICXFRWAYSTE	SWPP	MON	VICTORY HILL	NPPD	VICTORY HILL	NPPD	230/115
5507			CON	WAYSIDE	WAUE	STEGALL	WAUE	230
5508	NEBS56S40S55	SWPP	MON	NEBRASKA CITY	OPPD	SUB 3456	OPPD	345
5508			CON	SUB 3740	OPPD	SUB 3455	OPPD	345
5509	SIOTWIRAUHOS	SWPP	MON	SIOUX CITY	WAUE	TWIN CHURCH	NPPD	230
5509			CON	RAUN	MEC	HOSKINS	NPPD	345
5510	SIDOGASIDKEY	SWPP	MON	SIDNEY	NPPD	OGALALA	NPPD	230
5510			CON	SIDNEY	WAUE	KEYSTONE	NPPD	345
5511	HOBCARHOBALT	SWPP	MON	HOBART JUNCTION	CSWS	CARNEGIE	CSWS	138
5511			CON	HOBART JUNCTION	CSWS	ALTUS TAMARACK	CSWS	138
5512	PIREASPIRWHI	SWPP	MON	PIRKEY	CSWS	EASTON	CSWS	138
5512			CON	PIRKEY	CSWS	WHITNEY	CSWS	138
5514	ARSMCWARSTRI	SWPP	MON	ARSENAL HILL	CSWS	MCWILLE	CSWS	138
5514			CON	ARSENAL HILL	CSWS	FORTHUM	CSWS	138
5514			CON	FORTHUM	CSWS	TRICHEL	CSWS	138
5519	SPRWALSSHSTO	SWPP	MON	SPRING RIDGE	CSWS	WALNUT SPRINGS	CSWS	138
5519			CON	SW SHREVERPORT	CSWS	WESTERN ELECTRIC	CSWS	138
5519			CON	WESTERN ELECTRIC	CSWS	STONEWALL	CSWS	138
5520	EASWHIPIRKNO	SWPP	MON	EASTEX SWITCHING	CSWS	WHITNEY	CSWS	138
5520			CON	PIRKEY	CSWS	EASTON	CSWS	138
5520			CON	EASTON	CSWS	KNOX LEE	CSWS	138
5521	HOJHOCHOJMAR	SWPP	MON	HOBART JCT	CSWS	HOBART CITY	CSWS	69
5521			CON	HOBART JCT	CSWS	MARTHA	CSWS	138
5522	CRAASHANOFTS	SWPP	MON	CRAIG JCT	CSWS	ASHDOWN WEST	CSWS	138

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5522			CON	ANO	EES	FT.SMITH	OKGE	500
5523	ASHCRAANOFTS	SWPP	MON	ASHDOWN WEST	CSWS	CRAIG JCT	CSWS	138
5523			CON	ANO	EES	FT.SMITH	OKGE	500
5524	CRAASHSARLON	SWPP	MON	CRAIG JCT	CSWS	ASHDOWN WEST	CSWS	138
5524			CON	SAREPTA	EES	LONGWOOD	CSWS	345
5525	BONHACAESTAR	SWPP	MON	BONANZA	CSWS	HACKETT	CSWS	161
5525			CON	AES	OKGE	TARBY	OKGE	161
5526	REDMINAXTPOS	SWPP	MON	RED WILLOW	NPPD	MINGO	SECI	345
5526			CON	AXTELL	NPPD	POSTROCK	WR	345
5527	KNONHAPOSSHA	SWPP	MON	KNOLL	MIDW	NORTH HAYS	MIDW	115
5527			CON	POSTROCK	MIDW	SHAYS	MIDW	230
5528	SMOSUMMULCIR	SWPP	MON	SMOKEY HILLS	MIDW	SUMMIT	WR	230
5528			CON	MULLERGREN	SECI	CIRCLE	WR	230
5529	SPSNMTIES	SWPP	MON	SAN JUAN	SPS	CHAVES	SPS	230
5529			MON	TOLK	SPS	EDDY	SPS	345
5529			MON	YOAKUM	SPS	HOBBS	SPS	230
5530	SWEGRISWEAXT	SWPP	MON	SWEETWATER	NPPD	GRAND ISLAND	NPPD	345
5530			CON	SWEETWATER	NPPD	AXTELL	NPPD	345
5531	FTCRAUSHCHOS	SWPP	MON	FT CALHOUN	OPPD	RAUN	MEC	345
5531			CON	SHELL CREEK	NPPD	HOSKINS	NPPD	345
5532	MITCLERENWIC	SWPP	MON	MILAN TAP	SECI	CLEARWATER	WR	138
5532			CON	RENO	WR	WICH	WR	345
5533	EASESIEASSTJ	SWPP	MON	EASTTOWN	MPS	EAST SIDE	MPS	161
5533			CON	EASTTOWN	MPS	ST JOE	MPS	345
5534	HARRANNICAMA	SWPP	MON	HARRINGTON SUB	SPS	RANDALL	SPS	230
5534			CON	NICHOLS	SPS	AMARILLO SOUTH	SPS	230
5535	MRYMRYMIDSTJ	SWPP	MON	MARYVILLE	AECI	MARYVILLE	MPS	161
5535			CON	MIDWAY	MPS	ST JOE	MPS	161
5536	PITECKCLIHOL	SWPP	MON	PITTSVILLE	AECI	ECKLES	INDN	161
5536			CON	CLINTON	AECI	HOLDEN	AECI	161
5537	PATFULSARLON	SWPP	MON	PATMOS	EES	FULTON	CSWS	115
5537			CON	SAREPTA	EES	LONGWOOD	CSWS	345
5538	MOBSALTHHSAL	SWPP	MON	MOBERLY	AMRN	SALSBURY	KCPL	161
5538			CON	THOMAS HILL	AECI	SALSBURY	KCPL	161

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5539	NORSOUBUFNOR	SWPP	MON	NORFORK	SPA	SOUTHLAND	EES	161
5539			CON	BUFORD	SPA	NORFOLK	SPA	161
5540	EROAVOWASNEO	SWPP	MON	EAST ROGERS	CSWS	AVOCA	CSWS	161
5540			CON	WASHBURN	AECI	NEOSHO	SPA	161
5541	SWSCARONEWAS	SWPP	MON	SW STATION	CSWS	CARNEGIE	CSWS	138
5541			CON	ONEY	WFEC	WASHITA	WFEC	138
5542	HANMUSAGEPEC	SWPP	MON	HANNCOCK	OKGE	MUSKOGEE	OKGE	161
5542			CON	AGENCY	OKGE	PECAN CREEK	OKGE	161
5543	DEAXFRDEXFR2	SWPP	MON	DEAF SMITH	SPS	DEAF SMITH	SPS	230/115
5543			CON	DEAF SMITH	SPS	DEAF SMITH	SPS	230/115
5544	PLXXFRTOLLAM	SWPP	MON	PLANT X	SPS	PLANT X	SPS	230/115
5544			CON	TOLK	SPS	LAMB COUNTY	SPS	230
5545	TOLROOTOLROO	SWPP	MON	TOLK	SPS	ROOSEVELT	SPS	230
5545			CON	TUCO	SPS	TUCO	SPS	230
5546	TUCXFRTUCXFR	SWPP	MON	TUCO	SPS	TUCO	SPS	230/115
5546			CON	TUCO	SPS	TUCO	SPS	230/115
5547	TUCXFRTUCXF2	SWPP	MON	TUCO	SPS	TUCO	SPS	345/230
5547			CON	TUCO	SPS	TUCO	SPS	345/230
5548	SUNAMOTOLYOA	SWPP	MON	SUNDOWN	SPS	AMOCO	SPS	230
5548			CON	TOLK	SPS	YOAKUM	SPS	230
5549	GRAXFRLUBXFR	SWPP	MON	GRASSLAND	SPS	GRASSLAND	SPS	230/115
5549			CON	LUBBOCK SOUTH	SPS	LUBBOCK SOUTH	SPS	230/115
5550	POTXFRPECCAR	SWPP	MON	POTASH JCT	SPS	POTASH JCT	SPS	230/115
5550			CON	CARLSBAD	SPS	PECOS	SPS	115
5552	HOLXFRDOBGAN	SWPP	MON	HOLCOMB	SECI	HOLCOMB	SECI	345/1
5552			CON	DOBSON	SECI	GANO	SECI	115
5553	NEOXFRNEOXFR	SWPP	MON	NEOSHO	WR	NEOSHO	WR	345/161
5553			CON	NEOSHO	WR	NEOSHO	WR	345/138
5554	NEOXFRNEOXF2	SWPP	MON	NEOSHO	WR	NEOSHO	WR	345/138
5554			CON	NEOSHO	WR	NEOSHO	WR	345/161
5555	SUMXFRSUMXFR	SWPP	MON	SUMMIT	WR	SUMMIT	WR	230/115
5555			CON	SUMMIT	WR	SUMMIT	WR	230/115
5556	NEOXFRNEOXF3	SWPP	MON	NEOSHO	WR	NEOSHO	WR	161/138
5556			CON	NEOSHO	WR	NEOSHO	WR	345/161
5557	ROSELPROSSTE	SWPP	MON	ROSE HILL	WR	EL PASO	WR	138
5557			CON	ROSE HILL	WR	STEARMAN	WR	138

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5558	MEDSUNSPEXFR	SWPP	MON	MEDICINE LODGE	SECI	SUN CITY	SECI	138
5558			CON	SPEARVILLE	SECI	SPEARVILLE	SECI	230/115
5559	GRESHWNAVTER	SWPP	MON	SHAWNEE MISSION (GREENWOOD)	KCPL	SHAWNEE	KCPL	161
5559			CON	NAVY	KCPL	TERRACE	KCPL	161
5560	GREMETPENMUN	SWPP	MON	SHAWNEE MISSION (GREENWOOD)	KCPL	METRO	KACY	161
5560			CON	PENTAGON	WR	MUND	WR	115
5561	DOBGANHOLXFR	SWPP	MON	DOBSON	SECI	GANO	SECI	115
5561			CON	HOLCOMB	SECI	HOLCOMB	SECI	345/1
5562	SHAHAYPOSKNO	SWPP	MON	SOUTH HAYS	MIDW	HAYS	MIDW	115
5562			CON	POSTROCK	MIDW	KNOLL	MIDW	230
5563	WDWFPLTATNOW	SWPP	MON	WOODWARD	OKGE	FPL SWITCH	OKGE	138
5563			CON	TATONGA	OKGE	NORTHWEST	OKGE	345
5564	BUKSPRFINHIT	SWPP	MON	BUCKNER	SECI	SPEARVILLE	SECI	345
5564			CON	FINNEY	SPS	HITCHLAND	SPS	345
5565	LUBXFMJONHOL	SWPP	MON	LUBBOCK SE	SPS	LUBBOCK SE	SPS	230/69
5565			CON	JONES	SPS	HOLLY	SPS	230
5566	COPSTJCPFRSJ	SWPP	MON	COOPER	NPPD	ST JOE	MPS	345
5566			CON	COOPER	NPPD	FAIRPORT	AECI	345
5566			CON	FAIRPORT	AECI	ST JOE	MPS	345
5566			CON	FAIRPORT	AECI	FAIRPORT	AECI	345/161
5567	WODFPLWODXFR	SWPP	MON	WOODWARD	OKGE	FLP SWITCH	OKGE	138
5567			CON	WOODWARD	OKGE	WOODWARD	OKGE	138/69
5568	NWKANSASTIES	SWPP	MON	NESS CITY	SECI	RANSOM	SECI	115
5568			MON	NSI TAP	SECI	RULETON	SECI	115
5568			MON	PHILLIPSBURG	SECI	RHOADES	SECI	115
5568			MON	REDLINE	MIDW	BEACH	MIDW	115
5569	STEGALLXFMR	SWPP	MON	STEGALL	WAUE	STEGALL	WAUE	345/230
5570	OATHTRANSFMR	SWPP	MON	OAHE	WAUE	OAHE	WAUE	230/115
5571	WATFORDCXFMR	SWPP	MON	WATFORD CITY	WAUE	WATFORD CITY	WAUE	230/115
5572	NUNXFRNUNMAR	SWPP	MON	NEW UNDERWOOD	WAUE	NEW UNDERWOOD	WAUE	230/115
5572			CON	NEW UNDERWOOD	WAUE	MAURINE	WAUE	230
5573	LOGSWMLOGBLA	SWPP	MON	LOGAN	WAUE	SW MINOT	WAUE	115

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
5573			CON	LOGAN	WAUE	BLAISDELL	WAUE	230
5574	DAWLEWDAWMED	SWPP	MON	DAWSON COUNTY	WAUE	LEWIS	WAUE	115
5574			CON	DAWSON COUNTY	WAUE	MEDORA	WAUE	230
6006	GGS	SWPP	MON	GENTLMAN	NPPD	N.PLATTE	NPPD	230
6006			MON	GENTLMAN	NPPD	N.PLATTE	NPPD	230
6006			MON	GENTLMAN	NPPD	N.PLATTE	NPPD	230
6006			MON	GENTLMAN	NPPD	SWEETWATER	NPPD	345
6006			MON	GENTLMAN	NPPD	SWEETWATER	NPPD	345
6006			MON	GENTLMAN	NPPD	RED WILLOW	NPPD	345
6007	GENTLMREDWIL	SWPP	MON	GENTLEMAN	NPPD	RED WILLOW	NPPD	345
6008	GRIS_LNC	SWPP	MON	PAULINE	NPPD	MOORE (SHELDON)	NPPD	345
6008			MON	GRAND ISLAND	NPPD	COLUMBUS W.	NPPD	230
6008			MON	GRAND ISLAND	NPPD	MCCOOL	NPPD	345
6009	COOPER_S	SWPP	MON	COOPER	NPPD	ST. JOE	SJLP	345
6009			MON	COOPER	NPPD	FAIRPORT	AECI	345
6014	FTCAL_S	SWPP	MON	FT. CALHOUN	OPPD	SUB 3459	OPPD	345
6014			MON	FT. CALHOUN	OPPD	SUB 3454	OPPD	345
6014			MON	SUB 1251	OPPD	SUB 1297	OPPD	345
6030	NEBCTYCOOPER	SWPP	MON	COOPER	NPPD	NEBRASKA CITY	OPPD	345
6034	RAUN_TEKAMAH	SWPP	MON	RAUN	MEC	TEKAMAH	OPPD	161
6104	IATAN_EASTO	SWPP	MON	IATAN	KCPL	EASTOWNE	MPS	345
6125	SUBTEKRAUNEA	SWPP	MON	SUB 1226	OPPD	TEKAMHO	OPPD	161
6126	SUBTEKFTCRAU	SWPP	MON	SUB 1226	OPPD	TEKAMHO	OPPD	161
6126			CON	FORT CALHOUN	OPPD	RAUN	MEC	345
6146	TEKRAUCOONEB	SWPP	MON	TEKAMAH	OPPD	RAUN	MEC	161
6146			CON	FORT CALHOUN	OPPD	RAUN	MEC	345
6147	FTCAL_RAUN	SWPP	MON	FORT CALHOUN	OPPD	RAUN	MEC	345
6152	STMDSJFAFACO	SWPP	MON	ST. JOE	MPS	MIDWAY	MPS	161
6152			CON	ST. JOE	MPS	FAIRPORT	AECI	345
6152			CON	FAIRPORT	AECI	COOPER	NPPD	345
6177	GRISLDMCCOOL	SWPP	MON	GRAND ISLAND	NPPD	MCCOOL	NPPD	345
6548	SPLTSIOXSPSX	SWPP	MON	SPLIT ROCK	NSP	SIOUX FL	WAUE	230
6548			CON	SPLIT ROCK	NSP	SIOUX CITY	WAUE	345
6557	WATERTOWNXFM	SWPP	MON	WATERTOWN	WAUE	WATERTOWN	WAUE	345/230

IDC_NUMBER	FLOWGATE_NAME	FG_RC	ELEMENT TYPE	COMMON FROM NAME	FROM AREA	COMMON TO NAME	TO AREA	NOMINAL KV
6569	GAVYANGAVHAR	SWPP	MON	GAVINS POINT	WAUE	YANKTON JCT	WAUE	115
6569			CON	GAVINS POINT	WAUE	HARTINGTON	NPPD	115
6570	GAVHARGAVYAN	SWPP	MON	GAVINS POINT	WAUE	HARTINGTON	NPPD	115
6570			CON	GAVINS POINT	WAUE	YANKTON JCT	WAUE	115
6571	GAVSPIGAVHAR	SWPP	MON	GAVINS POINT	WAUE	SPIRIT MOUND	WAUE	115
6571			CON	GAVINS POINT	WAUE	HARTINGTON	NPPD	115
6572	GAVHARGAVSPI	SWPP	MON	GAVINS POINT	WAUE	HARTINGTON	NPPD	115
6572			CON	GAVINS POINT	WAUE	SPIRIT MOUND	WAUE	115
6573	GAVYANGAVSPI	SWPP	MON	GAVINS POINT	WAUE	YANKTON JCT	WAUE	115
6573			CON	GAVINS POINT	WAUE	SPIRIT MOUND	WAUE	115
6574	GAVSPIGAVYAN	SWPP	MON	GAVINS POINT	WAUE	SPIRIT MOUND	WAUE	115
6574			CON	GAVINS POINT	WAUE	YANKTON JCT	WAUE	115
9169	SIDNEY_W_E	SWPP	MON	SIDNEY DC TIE WEST	NPPD	SIDNEY DC TIE EAST	NPPD	DC
9170	MILESCITY_WE	SWPP	MON	MILES CITY WEST	WAUW	MILES CITY EAST	WAUE	230
9171	STEGALL_WE	SWPP	MON	STEGALL DC TIE	WSC5	STEGALL	WAUE	230
9173	BLKW_W_E	SWPP	MON	BLACKWATER DC TIE WEST	PNM	BLACKWATER DC TIE EAST	SPS	DC
9175	EDDYCO_W_E	SWPP	MON	EDDY COUNTY DC TIE WEST	EPE/TNP	EDDY COUNTY DC TIE EAST	SPS	DC
90996	LAMAR_W_E	SWPP	MON	LAMAR DC TIE WEST	PSCO	LAMAR DC TIE EAST	SPS	DC
90997	LAMAR_E_W	SWPP	MON	LAMAR DC TIE EAST	SPS	LAMAR DC TIE WEST	PSCO	DC
90998	EDDYCO_E_W	SWPP	MON	EDDY COUNTY DC TIE EAST	SPS	EDDY COUNTY DC TIE WEST	EPE/TNP	DC
90999	BLKW_E_W	SWPP	MON	BLACKWATER DC TIE EAST	SPS	BLACKWATER DC TIE WEST	PNM	DC

4. TVA Sub-Region

Number	Flowgate Name	Flowgate Owner
1	Mabelvale-Sheridan for loss of WhiteBluff-Sheridan	MISO
2	WhiteBluff-Sheridan for loss of Mabelvale-Sheridan	MISO
3	CaseyWest_Breed345_flo_WiltonCenter_Dumont765	MISO
4	COOPER_S	SWPP
5	1973_Russellville E-Russellville S 161kv FTLO ANO-Ft.Smith 500kv	MISO
6	8CHOCTAW 500/8W POINT 500 CKT 1 flo 8WELLS 500/8WEBRE 500 CKT 1	TVA

Number	Flowgate Name	Flowgate Owner
7	BREC Paradise Tap-Paradise FP 161 kV (flo) Barkley-Princeton 161 kV	MISO
8	8CHOCTAW 500/8W POINT 500 CKT 1	TVA
9	8CHOCTAW 500/8W POINT 500 CKT 1 flo 8MCADAM 500/6MCADAM 230 CKT 1	TVA
10	Clay-West Point 500 kV (flo) Clay 500/161 kV XFMR	TVA
11	Fontana - Hwy 411 161kV (flo) Fontana - Alcoa SS 161kV	TVA
12	5C-35 - 5C-37A #1 161kV (flo) 5C-35 - 5C-37A #2 161kV	TVA
13	8NEWPORT-6NEWPORT A5 MCGUIRE 500-230 A1	DUK
14	McAdams500-230 for loss of McAdams-Lakeover	MISO
15	CaseyWest_Breed345kV_flo_Loretto_WiltonCenter345kV	MISO
16	Freeport__Twinkletown_230_flo_Freeport__Hornlake_230	MISO
17	CasyWest_Breed345kV_flo_Lorretto_Pontiac345kV	MISO
18	HotSprings-Etta for loss of Sheridan-ElDorado	MISO
19	8KATRTRT-8OCONEE Z1 SOUTH MOUNTAIN	DUK
20	Batesville - Tallahatchie Ind Pk 161kV (flo) Choctaw - Clay 500 kV	TVA
21	PleasantPrairie_ZionEc345_FLO_PleasantPrairie_Zion_Arcadian_Zion	MISO
22	Iatan Xfr l/o Stranger - Iatan 345 kV	SWPP
23	Trimble Co.-Clifty Creek 345-Rockport-Jefferson 765	LGEE
24	Pontiac-Wilton Ctr 345 (flo) Pontiac-Dresden 345 + Pontiac 345/138 xfmr	PJM
25	Stranger - Craig 345 kV l/o St. Joe - Hawthorne 345kV	SWPP
26	Livingston-Barkley 161 kV (flo) Calvert-South Calvert 161 kV	TVA
27	Paradise FP - N Hardinsburg 161kV (flo) Volunteer - Phipps Bend NP 500kV	MISO
28	Paradise FP - N Hardinsburg 161 kV (flo) Zimmer-Zimmer G 345 kV	MISO
29	C33-Marshall 161 kV (flo) Shawnee-Marshall 500 kV	TVA
30	Freeport 500/161 kV XFMR (flo) Freeport-Cordova 500 kV	TVA
31	Sammis-Wylie Ridge 345	PJM
32	Volunteer-PhippsBend 500 kV (flo) Conasauga-Mosteller 500 kV	TVA
33	8TRINITY 500/5TRINITY 161 CKT 1 flo 8E POINT 500/5E POINT 161 CKT 1	TVA

5. Non RTO Midwest Sub-Region (provided by LGEE)

FG ID	Short Name	Long Name
1025	TRMCLFROCJEF	Trimble Co.-Clifty Creek 345-Rockport-Jefferson 765
2644	PARPFPBARPRI	BREC Paradise Tap-Paradise FP 161 kV (flo) Barkley-Princeton 161 kV
1658	C33MASHMAR	C33-Marshall 161 kV (flo) Shawnee-Marshall 500 kV
1661	LIVERLLIVCRD	Livingston Co-North Princeton 161 kV (flo) Livingston Co-Crittenden Co-Morganfield 161 kV
2837	WILGRVMATWIL	Wilson - Green River 161 kV (flo) Matanzas - Wilson 161 kV
2645	PARHARZIMZIG	Paradise FP - N Hardinsburg 161 kV (flo) Zimmer-Zimmer G 345 kV
1033	BRSGLSLAFSSH	Bristow - Glasgow 161 kV (flo) Lafayette - Summer Shade 161 kV

FG ID	Short Name	Long Name
1024	VOLPHBCONMOS	Volunteer-PhippsBend 500 kV (flo) Conasauga-Mosteller 500 kV
3179	EFRSHASTFLUT	EW Frankfort-Shawnee 345 (flo) St. Francois-Lutesville 345
2834	WILMATGRVWIL	Wilson - Matanzas 161 kV (flo) Green River - Wilson 161 kV
1034	LAFSSHEGLSSH	Lafayette - Summershade 161 kV (flo) E Glasgow - Summer Shade 161 kV
2209	WLXBRNBAKBRO	W.Lex-E.W.Brown345 (flo) Baker-Broadford765
1620	CBLDVSCBLJVL	Cumbland-DavidsonandCumbland-Jvill
2883	GRVRQT__PTDF	Green River-River Queen Tap 161
2201	BRNFWK__PTDF	Brown South-Fawkes 138 kV

Appendix D: Comparison between DOE Review Report and this Study

The DOE provided OATI with the "*Annual U.S. Transmission Data Review*" published in October 2016 which will be referred to as the "2016 U.S. Transmission Data Review" henceforth. A comparison was performed between this study and results provided in the 2016 U.S. Transmission Data Review with respect to top limiting market constraints.

PJM

The following table is from the 2016 U.S. Transmission Data Review which lists out the top 25 constraints, but does not describe their ranking procedure. These constraints are also a mixture of line, flowgates, interfaces, and transformers.

Table 5-6. PJM top 25 constraints with frequent occurrence, 2014-2015

			Congestion Event Hours						Percent of Annual Hours					
			Day-Ahead			Real-Time			Day-Ahead			Real-Time		
No.	Constraint	Type	2014	2015	Change	2014	2015	Change	2014	2015	Change	2014	2015	Change
1	Bagley - Graceton	Line	4,584	3,544	(1,040)	1,884	1,973	89	52%	40%	(12%)	22%	22%	1%
2	Oak Grove - Galesburg	Flowgate	6,905	3,356	(3,549)	1,059	1,306	247	79%	38%	(41%)	12%	15%	3%
3	Bunsonville - Eugene	Flowgate	2,244	3,762	1,518	675	748	73	26%	43%	17%	8%	9%	1%
4	Conastone - Northwest	Line	103	2,536	2,433	108	1,734	1,626	1%	29%	28%	1%	20%	19%
5	Maywood - Saddlebrook	Line	1,511	3,456	1,945	186	509	323	17%	39%	22%	2%	6%	4%
6	Tidd	Transformer	833	3,803	2,970	7	92	85	10%	43%	34%	0%	1%	1%
7	Bergen - New Milford	Line	4,745	2,970	(1,775)	331	795	464	54%	34%	(20%)	4%	9%	5%
8	Braidwood	Transformer	7,742	3,727	(4,015)	0	0	0	88%	42%	(46%)	0%	0%	0%
9	East Danville - Banister	Line	272	3,465	3,193	6	126	120	3%	39%	36%	0%	1%	1%
10	Monroe - Vineland	Line	1,348	3,121	1,773	24	197	173	15%	36%	20%	0%	2%	2%
11	Bedington - Black Oak	Interface	2,796	2,933	137	321	344	21	32%	33%	1%	4%	4%	0%
12	Easton	Transformer	1,758	3,099	1,341	0	0	0	20%	35%	15%	0%	0%	0%
13	Sayreville - Sayreville	Line	2,869	3,077	208	0	0	0	33%	35%	2%	0%	0%	0%
14	East Bend	Transformer	5,082	2,808	(2,274)	0	0	0	58%	32%	(26%)	0%	0%	0%
15	SENECA	Interface	3,562	938	(2,624)	3,227	1,182	(2,045)	41%	11%	(30%)	37%	13%	(23%)
16	Michigan City - Laporte	Flowgate	3,111	1,879	(1,232)	0	0	0	36%	21%	(14%)	0%	0%	0%
17	Tanners Creek	Transformer	8,096	1,838	(6,258)	0	0	0	92%	21%	(71%)	0%	0%	0%
18	Burnham - Munster	Flowgate	341	1,748	1,407	0	0	0	4%	20%	16%	0%	0%	0%
19	Miami Fort - Willey	Line	79	1,585	1,506	32	112	80	1%	18%	17%	0%	1%	1%
20	Cherry Valley	Transformer	2,762	789	(1,973)	324	885	561	32%	9%	(23%)	4%	10%	6%
21	49 Street - Hoboken	Line	394	1,643	1,249	0	0	0	4%	19%	14%	0%	0%	0%
22	Breed - Wheatland	Flowgate	3,758	1,358	(2,400)	602	149	(453)	43%	15%	(27%)	7%	2%	(5%)
23	Braidwood - East Frankfort	Line	1,245	1,449	204	25	58	33	14%	16%	2%	0%	1%	0%
24	Elwood - Elwood	Other	2,160	1,464	(696)	0	0	0	25%	17%	(8%)	0%	0%	0%
25	Bergen - Leonia	Line	2,128	1,456	(672)	0	0	0	24%	17%	(8%)	0%	0%	0%

The following tables are the top five binding constraints for the PJM sub-region from this study.

Binding Constraints Ranking By Count	Binding Constraints Name
1	Laporte-Michigan City 138 1 (MISO)
2	Burnham-Munster 345 (COMED-NIPS)

Binding Constraints Ranking By Count	Binding Constraints Name
3	Dixon-McGirr Road 10714 138 (COMED)
4	Crete-St. John 345 (COMED-MISO)
5	Maryland-11902 4 138 (COMED)

Binding Constraints Ranking By Cost	Binding Constraints Name
1	Dixon-McGirr Road 10714 138 (COMED)
2	Laporte-Michigan City 138 1 (MISO)
3	H471-Quad Cities 0404 345 (COMED)
4	Byron-Cherry Valley 0622 6 345 (COMED)
5	Byron-Wempletown 0624 345 (COMED)

Comparison results show the following constraints, including: Laporte-Michigan city, Burnham-Munster, and Byron-Cherry Valley which are listed in both reports. The congestion hours in both reports are also similar with each other but not the exact same numerical value.

ISONE

In the 2016 U.S. Transmission Data Review, no constraints list was provided. However, in the 2016 U.S. Transmission Data Review, ISONE provided the areas in ISONE territory which it considers to be constrained. The report lists SEMA/RI and NEMA/Boston capacity zones as the areas constrained.

The following tables contain top five binding constraints for the ISONE sub-region from this study.

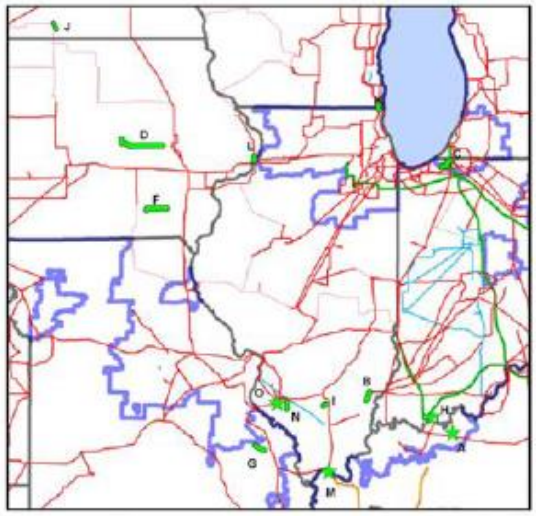
Binding Constraints Ranking By Count	Binding Constraints Name
1	326_SEABROOK_394-1_A
2	BASE_INTRFC_BERK
3	BASE_HAWKINS_250-517-3_A
4	BASE_INTRFC_ORR-SO
5	BASE_INTRFC_LRD1

Binding Constraints Ranking By Cost	Binding Constraints Name
1	326_SEABROOK_394-1_A
2	319_KNGSTN_S_345B_345B
3	BASE_INTRFC_SBRK_S
4	BASE_INTRFC_ORR-SO
5	BASE_HAWKINS_250-516-3_A

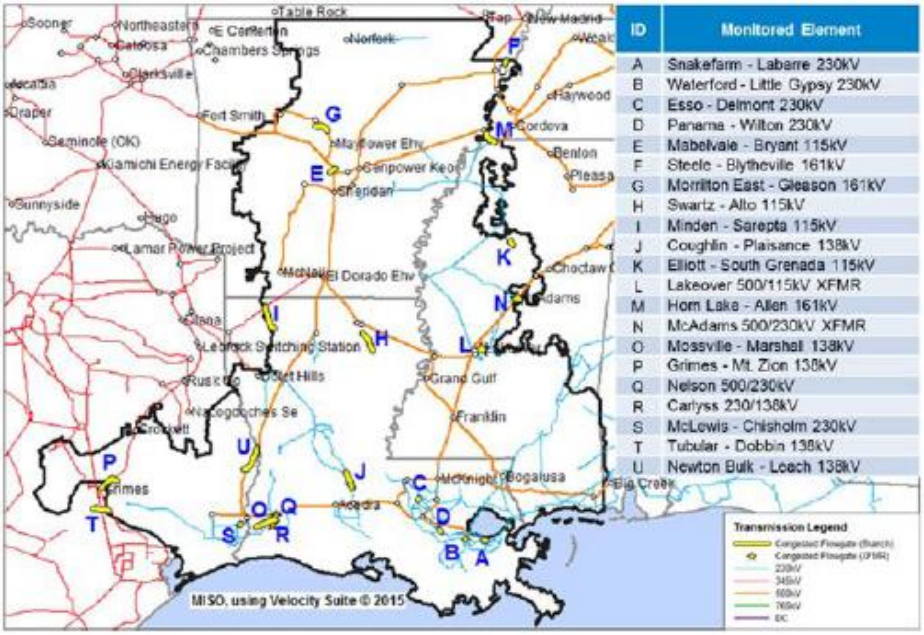
Comparison results show there are some consistencies between the 2016 U.S. Transmission Data Review and these study results, such as Flowgate 326_SEABROOK_394-1_A which is in the NEMA/Boston area and BASE_HAWKINS_250-516-3_A in the Boston area.

MISO

The 2016 U.S. Transmission Data Review lists out projected top future congested flowgates which were listed out in MISO's 2015 MTEP. In the 2016 U.S. Transmission Data Review, the future constraints are divided as MISO north, central, and south areas, while these study results did not classified them based on areas but as a whole MISO region. The figure from the 2016 U.S. Transmission Data Review below shows this region.



FG ID	Monitored Element
A	New Hardinsburg 138/161kV Transformer
B	Albion - Crossville 138kV
C	New Carlisle – Bosserman 138kV
D	Marshalltown - Blairstown Jct 115kV
F	Wapello - Jeff 161kV
G	Fredericktown - Fredericktown Tap 161kV
H*	Newtonville 138/161kV Transformer
I	Nason Point - Ina 138kV
J	Winnebago - Blue Earth 161kV
K	Pleasant Prairie – Zion EC 345kV
L	Quad City–Rock Creek 345kV
M	Joppa 345/161kV xfmr
N*	Tilden - Sparta Tap 138kV
O*	Baldwin 345/138kV xfmr



ID	Monitored Element
A	Snakefarm - Labarre 230kV
B	Waterford - Little Gypsy 230kV
C	Esso - Delmont 230kV
D	Panama - Wilton 230kV
E	Mabelvale - Bryant 115kV
F	Steele - Blytheville 161kV
G	Morrilton East - Gleason 161kV
H	Swartz - Alto 115kV
I	Minden - Sarepta 115kV
J	Coughlin - Plaisance 138kV
K	Elliott - South Grenada 115kV
L	Lakeover 500/115kV XFMR
M	Horn Lake - Allen 161kV
N	McAdams 500/230kV XFMR
O	Mossville - Marshall 138kV
P	Grimes - Mt. Zion 138kV
Q	Nelson 500/230kV
R	Carlyss 230/138kV
S	McLewis - Chisholm 230kV
T	Tubular - Dobbin 138kV
U	Newton Bulk - Leach 138kV

Figure 5-9. Projected top future congested flowgates in 2015 MTEP (Top: North/Central Area; Bottom: South Area)

The following tables contain the top five binding constraints for the MISO market from this study instead of the sub-region, as MISO did not provided the RT congestion cost for the study.

Binding Constraints Ranking By Count	Binding Constraints Name
1	Oak_Grove_Mercer161_flo_Nelson_ElectricJct
2	BUNSONVILL_EUGNE_SULLIVAN_CASEY
3	Eau_Claire_Arpin_345kV_flo_Stone_Lake_Gardner_Park_345kV
4	Rising_345_138_xfmr_flo_Clinton_Brokaw_345kV
5	Mercr_IP_Galesburg_161kV_flo_Nelson_Electric_Jct_345

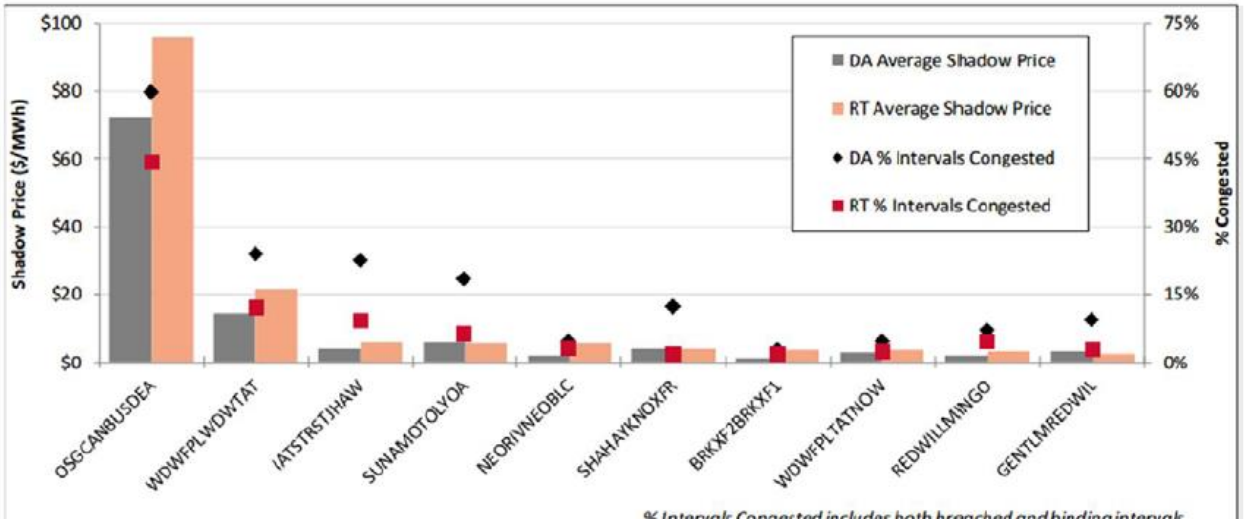
Binding Constraints Ranking By Cost	Binding Constraints Name
1	Oak_Grove_Mercer161_flo_Nelson_ElectricJct
2	Rising_345_138_xfmr_flo_Clinton_Brokaw_345kV
3	Batesvill_Hubbl_138kV_flo_Tanners_Creek_Miami_Fort_345kV
4	Mercr_IP_Galesburg_161kV_flo_Nelson_Electric_Jct_345
5	Munster_345_Trf_flo_WiltCen_Dumont

As only MISO market results were used rather than MISO sub-region results, this further reduced the number of binding constraints being considered for comparison. The comparison results show that there are no consistencies between the 2016 U.S. Transmission Data Review and these study results, as 2016 U.S. Transmission Data Review lists out future constraints from MISO TEP and this study had results for 2015.

SPP

The 2016 U.S. Transmission Data Review lists out the SPP congestion for 2014 with respect to shadow price whereas this study shows results for 2015 with respect to RT congestion cost.

Following graph is from DOE's review.



The following tables contain the top five binding constraints for the SPP sub-region from this study.

Binding Constraints Ranking By Count	Binding Constraints Name
1	WDWFPLTATNOW
2	OSGCANBUSDEA
3	TEMP56_21085
4	TMP169_21252
5	TMP144_21263

Binding Constraints Ranking By Cost	Binding Constraints Name
1	WDWFPLTATNOW
2	OSGCANBUSDEA
3	IATSTRSTJHAW
4	TEMP56_21085
5	TMP109_20517

Comparison results show there are some consistencies between the 2016 U.S. Transmission Data Review and these study results, even though the results in the reports show different years. These study results also have some temporary constraints which may not be seen in upcoming

years. It can also be seen that these three constraints (OSGCANBUSDEA, WDWFPLTATNOW, and IATSTRSTJHAW) do show up in both the results.

NYISO

The following table from the 2016 U.S. Transmission Data Review lists out constraints by congested hours.

Table 5-5. Number of congested hours by constraint, actual and projected

# of DAM Congested Hours	Actual					CARIS Base Case Projected									
Constraint	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CENTRAL EAST	2,968	2,166	1,471	3,374	3,022	4,678	4,215	4,527	4,425	4,416	3,466	3,624	3,365	3,469	3,203
DUNWOODIE TO LONG ISLAND	4,513	6,219	4,777	6,031	5,583	7,869	7,667	7,778	7,502	7,517	7,840	7,920	7,908	8,056	8,108
LEEDS PLEASANT VALLEY	673	514	392	624	384	961	546	629	475	410	325	349	353	404	767
GREENWOOD	2,705	4,338	2,983	3,415	1,438	8,096	7,591	7,693	7,873	7,817	8,392	8,357	8,402	8,430	8,442
NEW SCOTLAND LEEDS	156	774	69	264	173	145	17	29	7	9	9	11	17	13	6
PACKARD HUNTLEY	-	-	-	-	308	3,604	4,729	4,816	5,019	4,809	4,449	4,326	4,209	4,291	4,112
DUNWOODIE MOTTHAVEN	765	828	644	504	190	0	0	0	1	0	0	0	0	0	0
RAINEY VERNON	3,131	3,785	2,166	2,166	641	410	4,953	5,308	5,409	5,388	5,142	5,381	4,930	5,223	5,070
E179THST HELLGT ASTORIAE	3,371	4,880	2,432	2,182	990	410	787	864	796	728	563	740	719	737	736
EGRDNCTY 138 VALLYSTR 138	1,880	2,812	2,934	5,908	5,142	2,183	5,491	5,962	5,727	6,086	5,009	5,491	5,574	5,791	5,780

The following tables show the top five binding constraints for the NYISO sub-region from this study.

Binding Constraints Ranking By Count	Binding Constraints Name
1	CENTRAL EAST - VC
2	GOWANUS 138 GREENWD 138 1
3	EGRDNCTY 138 VALLYSTR 138 1
4	DUNWODIE 345 SHORE_RD 345 1
5	GREENWD 138 VERNON 138 1

Binding Constraints Ranking By Cost	Binding Constraints Name
1	EGRDNCTY 138 VALLYSTR 138 1
2	PACKARD 230 SAWYER 230 1
3	CENTRAL EAST - VC
4	GREENWD 138 VERNON 138 1
5	GOWANUS 138 GREENWD 138 1

Comparison results show CENTRAL EAST - VC, GOWANUS 138 GREENWD 138 1 and EGRDNCTY 138 VALLYSTR 138 1 are listed in both reports.